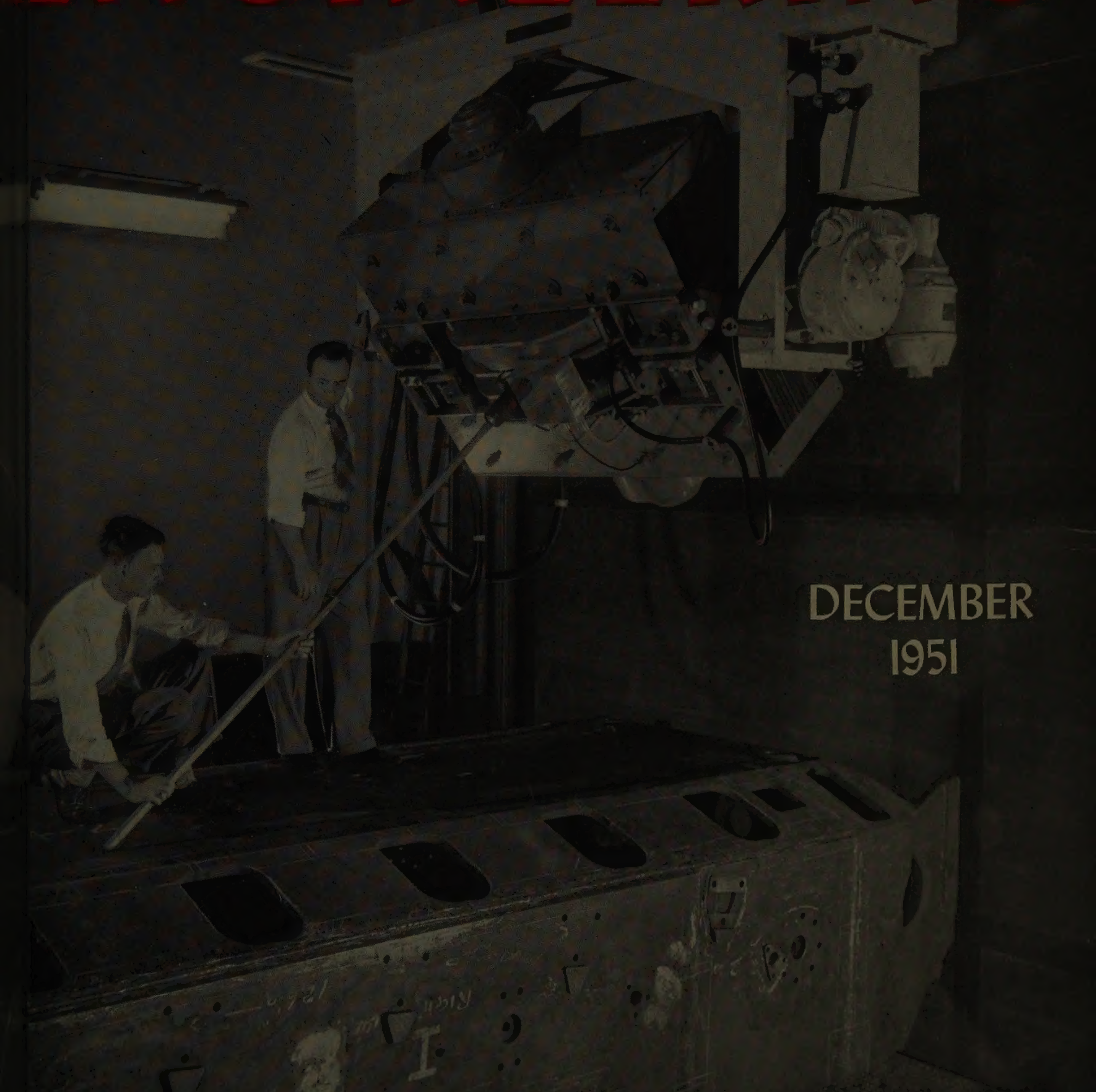
ELECTRICAL ENGINEERING



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The Cover: This 20,000,000-volt motorized betatron is now in operation at the Continental Foundry and Machine Company, Chicago, Ill., for inspection of heavy ordnance equipment. Built by the Allis-Chalmers Manufacturing Company, it can detect flaws as small as 0.02 inch in 24-inch-thick sections.

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HIGHLIGHTS........

Your Stake in Atomic Energy. The major concern of the Atomic Energy Commission is to make certain that the stock of weapons continues to grow at an accelerated rate, says Commissioner T. K. Glennan. But, of course, the Commission is also concerned with peacetime applications of atomic energy as, for example, the production of radioisotopes for use in medicine, industry, and agriculture (*pages 1033–38*).

Fire Protection in Electric Stations. The fundamentals of fire protection in electric stations are dealt with, and some fires which have occurred on the Consolidated Edison System are discussed. The authors place emphasis on equipment design which will reduce the possibility of fires (*pages 1040–45*).

Statistical Methods in a Utility. Engineers frequently turn to statistical methods for solving problems having large amounts of data. This month a statistical engineer describes a number of typical problems that were solved by such methods in one large utility (*pages 1047–49*).

Blocking-Tube Oscillator Design. Electron-tube circuit designers will find this article a comprehensive survey of the various factors which enter into the design of a blocking-tube oscillator for television receivers. A quantitative analysis of the oscillator cycle is given, and synchronized operation and noise immunity are discussed (*pages 1050–55*).

Lightning Hazards in Japan. Transmission-line engineers will be interested in this article, which is a report on an extensive survey of the occurrence of lightning in Japan and the effects that it has had on the operation of power lines. The number and types of service interruptions on various types of transmission lines are reported (*pages 1065–67*).

News Index

Loudspeaker Systems in Power Plants. Although power plants have a variety of facilities for communication within the plant, a public address system often makes a useful supplement, providing a means for individual or group paging, conveying orders to groups of people simultaneously, a means of communication from any one of these individuals to the entire group, and a means of notifying all personnel in cases of emergency (*pages 1057–62*).

Cable Sheath Problems and Design. With some 300,000 circuit miles of cable sheath in its communications network, the Bell System requires dependable sheath design to protect its cables against the whims of nature and man. The engineering of these cable installations is a complex problem requiring a satisfactory balance between costs and the quality of service required (*pages 1070–75*).

Conductor Vibration in Transmission Lines. Exhaustive laboratory tests as well as extensive operating experience have led to the conclusion that lower conductor tensions in transmission lines appreciably reduce vibration, and thus increase the useful life of the conductor. The author also discusses the importance of properly supporting and splicing the conductors as well as a method for estimating the probable conductor life (*pages 1078–82*).

A Static Magnetic Exciter. An analysis of the equivalent circuit and equations of an alternator has led to the design of a voltage regulator for the machine which has a high degree of regulation as well as an excellent transient response. The analysis of the machine, the design of the corrective circuit, and the performance of the circuit in the machine are presented (*pages 1084–88*).

A Short-Haul Microwave Link. With hundreds of miles of microwave repeater telegraph circuits crisscrossing the country, the need arises for a means of tying in and cutting out blocks of traffic to localities off the main trunk lines. To fill this need, the Western Union Company has developed a single-hop pulse-amplitude modulated system with simplified microwave circuits and few of the fancy trappings of trunk line equipment (*pages 1094–99*).

Improving Switch Sensitivity with Feedback. Linear feedback analysis methods commonly applied to electron-tube amplifiers are applied to reversible switches. By this means it is possible to achieve varying degrees of switch sensitivity and to determine the maximum degree of sensitivity that can be achieved. A graphical method for making this analysis is presented (*pages 1100–04*).

AIEE Proceedings

Order forms for current AIEE *Proceedings* have been published in *Electrical Engineering* as listed below. Each section of AIEE *Proceedings* contains the full, formal text of a technical program paper, including discussion, if any, as it will appear in the annual volume of AIEE *Transactions.*

AIEE *Proceedings* are an interim membership service, issued in accordance with the revised publication policy that became effective January 1947 (*EE, Dec '46, pp 567–8; Jan '47, pp 82–3*). They are available to AIEE Student members, Affiliates, Associate Members, Members, and Fellows.

All technical papers issued as AIEE *Proceedings* will appear in *Electrical Engineering* in abbreviated form.

Location of Order Forms	Meetings Covered
Nov '50, p 44A	Middle Eastern District Fall General (1950)
Mar '51, p 35A	Winter General
Jul '51, p 23A	Southern District North Eastern District Great Lakes District Summer General
Nov '51, p 37A	Pacific General Fall General

A Tribute to D. C. Jackson. At the memorial services for the late Professor Dugald C. Jackson, Vannevar Bush delivered the address presented here (*pages 1063–64*).

An Improved Polar Telegraph Relay. This new relay design is a typical product of the engineer's ceaseless efforts for improvement. Although some years ago polar relays attained transmission efficiencies which left little to be desired, further attack on the design problems has led to improvement in dependability, substantial reduction in size and cost, increase in maintenance-free life, and promises of important new applications (*pages 1088–92*).

Membership in the American Institute of Electrical Engineers, including a subscription to this publication, is open to most electrical engineers. Complete information as to the membership grades, qualifications, and fees may be obtained from Mr. H. H. Henline, Secretary, 33 West 39th Street, New York 18, N. Y.

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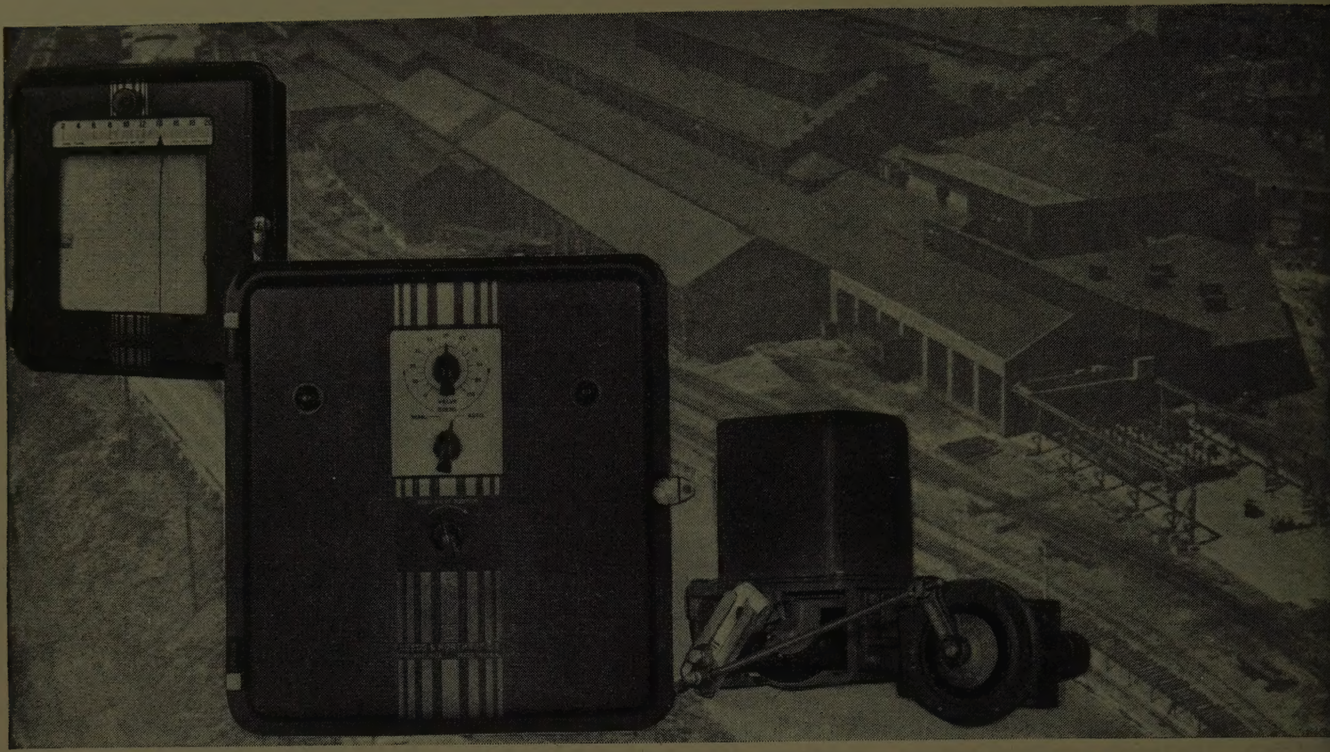

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Your Stake in Atomic Energy

T. K. GLENNAN

The atomic energy industry, and the important part played in that industry by the electrical engineer, are described by T. K. Glennan, AEC Commissioner. The Commission's attempts to find useful peacetime applications are presented. The necessity for a continuing and increasing supply of engineers for the prosecution of the atomic energy program is stressed.

AS A RENEGADE electrical engineer of the vintage of 1927, I feel a little presumptuous in appearing before this group today. As a member of the Atomic Energy Commission (AEC), however, I count it a privilege to have the opportunity of bringing to you a factual picture of the Commission's program. It is my conviction that too many people know too little about those portions of this program which can be publicly reported without violating security regulations. This conviction has led me to adopt the practice of limiting most of my public remarks to a discussion of those aspects of the program which are or should be of special interest to the particular audience to which I may be talking. Perhaps I can thus indicate your stake in atomic energy.

Anyone trying to assemble remarks on electrical engineers and their relation to atomic energy operations and development is likely to find himself with more facts to report and ideas to expound than can be fitted into the allotted time. In the limited time I had for composing this address (if you have read the papers you will understand that these past few weeks have been hectic ones for the Commission), I found it impossible to put the many available pieces together into a smooth-flowing product. So I resorted to a technique that the developmental electrical engineers in our business find it necessary to use now and then. They say they just "throw the switch, stand back, and look for smoke."

Well, I'll throw the switch, and you can stand back and look for the smoke, if any. Without trying to assemble them into a logical whole, I'll try to cover four points:

1. The size and shape of the atomic energy industry of the United States.
2. The part of the electrical engineer in atomic energy development.
3. The present stage of development of power-producing machines burning nuclear fuels and relations between the electric power industry and the AEC.
4. The need for and prospective supply of engineers in atomic energy work.

THE ATOMIC ENERGY INDUSTRY OF THE UNITED STATES

THE ATOMIC ENERGY industry is owned by the people of the United States and is operated and managed by the Atomic Energy Commission, an agency of government. Its charter is the Atomic Energy Act of 1946, which defines the objectives of the operation in a noble declaration of policy which is well worth noting here: "It is hereby declared to be the policy of the people of the United States that—subject at all times to the paramount objective of assuring the common defense and security—the development and utilization of atomic energy shall, so far as practicable, be directed toward improving the public welfare, increasing the standard of living, strengthening free competition in private enterprise and promoting world peace."

The law also says, "It shall be unlawful for any person to own any facilities for the production of fissionable materials or for any person to produce fissionable material. . . . " Fissionable materials, as you know, mean chiefly uranium and man-made plutonium.

It looks as if the law has set up the AEC as the operator of a tight government monopoly. This is true to the extent that the business is controlled, and largely owned, by the Government. But there the similarity to monopoly ends, in my opinion.

Much of our activity is industrial in nature; our products are the results of industrial operations. These operations are performed—for the most part—by private industrial concerns or educational institutions.

On the industrial side the list of contractors is so long that it would take 15 minutes to give you the names of just the major companies working with the Commission. Among them are: Dow Chemical Company, the Du Pont Company, General Electric Company, Westinghouse Electric Corporation, Carbide and Carbon Chemicals Company (a division of Union Carbide and Carbon Corporation), Phillips Petroleum Company, Harshaw Chemical Company, American Cyanamid Company, Monsanto Chemical Company, and so forth.

Over 200 educational institutions play an equally large part in the research and development phases of the atomic energy program. Typical of these operations are such establishments as:

Brookhaven National Laboratory, a center for basic research on Long Island, N. Y., operated by nine of the leading eastern universities.

Argonne National Laboratory, a reactor development center in Chicago, Ill., operated by the University of Chicago with 31 midwestern universities participating in the program.

Full text of an address presented at the AIEE Fall General Meeting, Cleveland, Ohio, October 22–26, 1951.

T. K. Glennan is Commissioner, United States Atomic Energy Commission, Washington, D. C. He is on leave from his post as President of Case Institute of Technology, Cleveland, Ohio.

The Oak Ridge Institute for Nuclear Studies, operated by 28 of the southern and southwestern universities.

The Los Alamos Scientific Laboratory, a weapons development center operated by the University of California.

The Ames Laboratory, a metals research center operated by Iowa State College.

The Radiation Laboratory, a particle accelerator research center at Berkeley, Calif., operated by the University of California.

A Medical Research Center in Rochester, N. Y., operated by the University of Rochester.

The atom business, it is clear, is run largely by industrial and scientific people. There are more than 100,000 persons working directly in the program. Less than 6,000 of these are now on the AEC payrolls. The rest work for our contractors. About 48,000 are employed in our "factories" and laboratories. More than 50,000 are construction people who are building the many new plants and other facilities that are part of the present expansion program.

Here are several facts that help one grasp the magnitude of the atom business. The AEC owns or controls 44 parcels of land in 24 states and the District of Columbia. The parcels range from a few hundred square feet of rented office space in a large city to the 400,000-acre reservations in the states of Washington and Idaho and the Eniwetok Atoll in the Pacific. Add up all this acreage and you have almost 3,000 square miles. That's almost half again larger than the state of Delaware.

The AEC is landlord and municipal housekeeper for some 70,000 men, women, and children in three government-owned atomic cities. They are Oak Ridge, Tenn., the oldest, with more than 31,000 population; Richland, Wash., with about 24,000; and Los Alamos, on a mesa-top in New Mexico, with 13,000. We do not want any more. Operation of these cities accounts for an approximate 5 per cent of our budget but sometimes it seems that it brings on 90 per cent of our headaches.

FOUR STEPS IN MANUFACTURING

LET'S MOVE NOW from statistics to the actual manufacturing process. You might picture the atomic energy manufacturing process as an inverted pyramid resting on a narrow base labeled "uranium ore." We are making every possible effort all over the free world to broaden that base.

The United States continues to receive a substantial portion of its uranium from the Belgian Congo and Canada. The intensive search in our own country, however, is beginning to pay off and domestic production is playing an increasingly important role, actually surpassing Canadian production at this moment.

Uranium is about as plentiful in the earth's crust as lead. But a perverse nature has so widely distributed it that concentrated deposits are quite rare. For example, there are tons of the stuff in the Tennessee shales but the amount—in ratio to each ton of shale—is so small that recovery at present is not commercially feasible.

Fortunately, there are instances where it is possible to get uranium from very low-grade sources. It can be recovered as a by-product in the treatment of certain South African gold ores. Also, it is technically feasible to recover the uranium contained in phosphate rock as a by-product in the manufacture of fertilizer or other phosphatic products.

After mining, the next step is processing the ore. This is done in a number of private industrial plants about the country. To provide additional capacity, we are now building a $54,000,000 processing plant at Fernald, Ohio, which the National Lead Company will operate for us. The end product of this processing activity emerges in two forms: natural uranium metal and uranium in a gaseous form known as UF_6, or uranium hexafluoride.

That brings us to the third step—the manufacture of fissionable materials. The uranium metal goes to Hanford, Wash., to be "cooked" in the giant reactors there, to produce plutonium. The uranium in gaseous form goes to Oak Ridge, Tenn., where the more useful U-235 atoms are separated from the more numerous U-238 atoms in those great plants that house the gaseous diffusion process.

Here, again, we are expanding our capacity. The half-billion dollar investment being made at Paducah, Ky., and the new billion-dollar plus Savannah River Plant under construction in South Carolina will produce fissionable materials.

The fourth step is the preparation for the manufacture of reactor fuel and weapon parts. At Hanford, the plutonium in its original state is in solution along with a lot of stuff-fission products, we call them, and has to be separated and converted into metal. Likewise, at Oak Ridge, the gaseous concentrated U-235 has to be made into metal.

The production line up to this point is the same whether you are desirous of building nuclear hearts of weapons or fashioning enriched fuel for reactors to produce power or to make radioactive isotopes. Today, as you must know, the emphasis is on weapons. I can assure you that the major concern of the Commission is to make certain that our stock of weapons continues to grow at an accelerated rate. The designing of new and improved weapons is an important part of our military program and is integrated closely with the stated requirements of the military services. As in any developmental program, tests must be conducted and for this purpose we carry on operations at Eniwetok Atoll in the Pacific and at the Las Vegas test site in Nevada where developmental tests are currently under way.

In Operation Greenhouse in the spring of this year, the weapons exploded on the Eniwetok testing ground were several times more powerful than the bombs dropped on Hiroshima and Nagasaki. We have said that we are now producing atomic weapons on an industrial basis. Beyond these statements we will not go this morning. One day the whole story can and will be told, but right now let's look at some other aspects of the atom business.

OTHER ASPECTS OF THE PROGRAM

ONE PART OF THE program which could itself be the subject of a long—and I would hope interesting—talk

should be mentioned briefly. This is our production of radioisotopes for use in medicine, in industry, in agriculture, and in physical and biological research of hundreds of types. We make these substances principally at Oak Ridge and sell them at cost to qualified users. Since 1946 when the Manhattan Engineer District started distributing them, more than 19,000 shipments of isotopes have gone out from our plant. The British and the Canadians too make and sell radioisotopes.

They are a new tool for science around the world, a tool of greater power and use than any other tool developed for investigators since van Leeuwenhoek invented the microscope 300 years ago. They are more: some isotopes of certain of the elements are the means of diagnosis and healing in medicine and are the source of radiation used in many industrial process control operations.

While I am about it, I'd like to touch briefly on the importance placed by the Commission on research. Without new findings in basic science you cannot have new products and processes. Our scientist colleague on the Commission, Dr. Henry D. Smyth, succinctly stated the urgency of basic research in an address before the Association for the Advancement of Science last December. He said then: "In World War II, for the first time in history, we pushed our development of weapons close to the limits of our basic knowledge. Discoveries in science less than five years old were put to use in the atomic bomb and other weapons. This may happen again, but only if there is new knowledge to put to use."

T. Keith Glennan

The AEC is financing and stimulating the acquisition of new knowledge in its field. Some $40,000,000 annually is going into research in the physical and the biological sciences.

There are other points I would like to make, but I will content myself with just two: the security and the safety activities of the atomic energy program consume a large amount of effort and funds. We feel that the record of the AEC on both points is good, but we are not letting up on either front—in fact, we are continuously trying to improve security provisions and safety practices throughout the project.

Now, with the hope that thus far I have given you a condensed but useful picture of the Commission's operations, I'd like to turn to a discussion of the part played by engineers in this business with particular attention to the activities of the electrical engineer.

THE DIRECT PART OF THE ELECTRICAL ENGINEER IN THE ATOM BUSINESS

Along with scientists, engineers are the key men of atomic energy development. Without engineers, we couldn't reach our objectives. The close working relationship, noted before in Dr. Smyth's quotation, between research and development in modern industry has brought about a situation where about half our technical workers are engineers and half are scientists. As for the governmental management of the enterprise, it is drawn in the main from the engineering profession. It is worth noting that the General Manager and the Deputy and Assistant General Managers are engineers; each of the ten Managers of Operations is an engineer; and two of the five Commissioners were trained as engineers. The engineering viewpoint and approach bulk large both in making atomic energy policy and conducting day-to-day atomic energy operations.

Of the approximately 6,400 engineers in the program (excluding construction operations) last June 30, nearly one-fourth were electrical and radio engineers—approximately 1,500. Only mechanical engineers surpassed the electrical-radio group in number and they by a small margin. This is some indication of the importance of electrical engineering in atomic energy operations and development.

What do electrical engineers do on the project? The answer was given in a brief but informative paper[1] by D. W. Cardwell of the Oak Ridge National Laboratory which was declassified and published about three years ago. He pointed out, to put it in broad terms, that electrical engineers supply power for the processes of the industry, they provide process control, and they furnish instrumentation of various sorts. Specifically, he reported their part in high-energy particle accelerator work; in radiation instrument development; in the design of equipment for and in the operation of the separation plants at Oak Ridge; and in reactor development, both for production and for power and propulsion purposes.

The Particle-Accelerator Field: You will notice that this group of functions cuts well across the whole spectrum of atomic energy operations and development. They involve some really difficult pioneering problems as well as unspectacular day-to-day operating functions. Take the field of the particle accelerator. This is still the fundamental tool of physical research in atomic energy. It

comprises cyclotrons, betatrons, synchrotrons, cosmotrons, van de Graafs, and so forth. They are so useful that there are now more than 70 of them in operation in this country, nearly all financed at least partially by the Atomic Energy Commission. The later designs have progressed to such size—130-foot diameter for the new one abuilding at the Radiation Laboratory, for example—that the electrical engineering problems are enormous; they are unprecedented. It is in this field that even the most experienced and ingenious engineers have to follow the formula, time and again, of testing their new designs by "throwing the switch, standing back and watching for smoke." For specific examples of these tasks I commend you to Cardwell's paper, with the reminder that since Cardwell wrote in 1948 there has been a quantum jump in the complexity and difficulty of accelerator work.

The Radiation Field: A characteristic phenomenon accompanying the release of atomic energy is radioactivity. Instruments for detecting and measuring radioactivity are required, in quantity, at numerous points in atomic energy processes. They are used to guard the health of the men and women working in plants and laboratories; in radioactive chemical assaying; and in process monitoring. Most of the basic ideas for radiation detection devices have come from scientists, but the developmental work has become more and more exclusively the field of the electrical engineer. And here is an atomic energy field where private enterprise has moved in vigorously. The demand for better, more rugged, more sensitive devices mounts higher and higher. These market needs are being met in increasing volume by industrial concerns. It is a field, by the way, with direct relation to the common defense and security at many points, not least in the area of civil defense monitoring equipment.

Reactor Development: In the development of reactors, the basic machines for making fissionable materials and isotopes, and the hope for production of electric power from nuclear fuels, the electrical engineer is called upon again and again. Some of his toughest problems cluster around the development of the mechanisms that are needed to regulate accurately the power level of operation. Physicists and electrical engineers have worked out a variety of complicated servomechanisms to bring this about. They have combined their efforts to develop electronic devices and circuits that enable the reactor theoreticians, in their design studies, to simulate mathematical pile power relationships and represent the distributions of neutron flux within the operational space of the reactor.

Oak Ridge Separation Plants: In the design and construction of the great uranium isotope separation plants at Oak Ridge, one of the two major sources of fissionable materials, the electrical engineers were called upon to perform semimiracles. In the Manhattan District days, Oak Ridge employed the largest group of electrical engineers ever brought together for one general project. Some worked on the electromagnetic process, the first to produce uranium 235, though this method has since been abandoned in favor of the gaseous diffusion process.

These great diffusion plants at Oak Ridge, on which we now rely for separation of the fissionable U-235 atoms from the more plentiful U-238 atoms, are in being partly as a result of electrical engineering imagination. In fact, the electrical engineers worked themselves and their fellow engineers out of a lot of jobs by successfully designing for K-25 and its sister plants automatic control systems that require very few operators.

Before leaving this portion of the discussion, it should be noted that these electrical engineers have a substantial responsibility for the power supply for our atomic energy plants. Most of the power comes from the commercial or public systems, although some of it is generated on-site at, for example, Oak Ridge and Hanford, either to provide for a supply of greater reliability than can be expected from the general grid, or to provide spare capacity against emergency.

When the present expansion of production plants to which I have referred previously is completed, the AEC will be beyond compare the largest single user of electric power in this country—and I presume that means in the world.

STATUS OF POWER FROM ATOMIC ENERGY FUELS AND RELATIONS BETWEEN THE AEC AND THE ELECTRICAL INDUSTRY

At this point it might be worth while taking a look at the relationships between the electrical power industry and the AEC and to discuss briefly the present stage of development of power-producing machines burning nuclear fuels. That the AEC system should be a very large user of current, adding to the burden on the electrical generating capacity of the nation, seems paradoxical and painful to those readers of the Sunday supplements who look to nuclear reactors as a new and cheaper source of electric power to lift the burden of man's drudgery. The atomic energy development program expects to vindicate the hopes of those who are confident of finding in uranium and thorium and reactors a new power supply. But it will be some time before atomic energy machines will produce as much power as the atomic energy industry consumes.

There isn't time available to me this morning to describe in detail those AEC projects which have been undertaken for the purpose of exploring techniques which might be applicable in the power generation field. These projects include the reactors under design and development for propulsion of submarines and aircraft and experimental devices in the test phase or nearing completion at the reactor test station in Idaho. Numbered in the latter category are the experimental breeder reactor and the materials testing reactor, both of which will provide useful data for future developmental work.

The AEC continues to maintain, in spite of the pressure of its weapons activities, a vigorous research and developmental program in this field. But we are not the only ones who have a stake in the development of such machines; obviously, if this should turn out to be an economical source of power, the power-making and power-using industries will be affected.

It is thus natural that industry should be interested in

he development of power reactors. It has been difficult o find ways and means, because of the monopolistic haracter and the security requirements of the AEC, of naking this interest effective in speeding development. Now it appears that progress is being made.

The Commission is very much pleased that four groups of firms have entered into agreements under which they are assigning, at their own expense, their best technical men and employing qualified consultants to study the reactor program. Eight major companies, including Dow Chemical Company, Detroit Edison Company, Bechtel Corporation, Pacific Gas & Electric Company, Monsanto Chemical Company, Union Electric Company, Commonwealth Edison Company, and Public Service Company of Northern Illinois, are actively engaged in these studies.

The agreements provide for the making of analyses by the companies to (a) determine the engineering feasibility of their designing, constructing, and operating dual-purpose reactors to produce fissionable materials and power; (b) examine the economic and technical aspects of building such reactors in the next few years; (c) determine the possible research and development needed to validate their design thinking; and (d) recommend industry's role in designing, building, and operating such reactors.

Since only a limited number of studies are being undertaken and since they will be based on information acquired at public expense, yet not generally available to the public, AEC will determine the disposition of patent rights and use of reports to be made as a result of these studies.

When and if it is feasible to produce commercial power many public policy decisions will be involved and the present atomic energy law may have to be changed. If you are familiar with the McMahon Act, you will remember these words: "Whenever in its opinion any industrial, commercial, or other non-military use of fissionable material or atomic energy has been sufficiently developed to be of practical value, the Commission shall prepare a report to the President stating all the facts with respect to such use; the Commission's estimate of the social, political, economic and international effects of such use and the Commission's recommendations for necessary or desirable supplemental legislation. The President shall then transmit this report to the Congress, together with his recommendations."

Thus, if the work being done by these four teams of industrial concerns should result in proposals for commercial power production and the formulation of a report as required by the Act, they will have rendered a real service not only to themselves, but to the people and industry generally. They will have brought into focus the economic problems of power production from nuclear fuels.

For myself, I am greatly heartened that these concerns are investing their own funds in such pioneering effort. Their action is an example of what free enterprise really means; and thank goodness it still persists and thrives, even in the face of the peculiar conditions and difficulties surrounding atomic energy development in an embattled world. Success in applying the push of private investment and initiative in this field will broaden the opportunities and increase the complexities of the electrical engineer's job.

WHERE TO GET ENGINEERS IN THE FUTURE?

AND NOW LET ME discuss just for a moment an item of very considerable importance to the future welfare of this nation. In the atomic energy business we are smack up against the shortage of trained engineers and scientists. This is a tale of woe which must be all too familiar to the men in this audience. The reasons for it you must know in part, but let me list a few of the most important.

(1) The demand for engineers has increased by reason of:

(*a*) A tremendous expansion in the amount of research and development effort supported by government and industry during and since World War II.

(*b*) The design, building, and operating of new plants to manufacture the products and devices resulting from that research and development effort.

(*c*) Full employment with a high national income level pushing up the market for products of all kinds throughout the economy.

(2) On the other hand, the supply of engineers is decreasing drastically as the result of a decreased enrollment in technical schools due in part to the low birth rate of the early 1930's and in part to poor guessing on the part of educators and government statisticians as to the probable future market for engineers.

While we may blame the statisticians for misreading the trend or giving too much weight to temporary decreases in demand, we must blame ourselves, in my opinion, for our inability to realize that the most precious ingredient in any product is the manpower that conceives, designs, manufactures, and distributes it. In each of these vital steps the engineer is to be found in increasing numbers and yet we as industrialists and employers will invest more money on specialized materials for new processes than we will on specialized and well-trained manpower. We stockpile raw materials but expect that good men will be educated and available through some magic process or other without effort or interest on our part.

I speak with feeling on this matter because of the effect that this present and continuing shortage of well-trained men is having on the Commission's program and because of the personal knowledge I have of the financial and enrollment problems faced by most of the nation's finest institutions of higher learning in the fields of science and technology when these demands fluctuate. And I speak of it as well because there is something that each of you can do about it.

I assume that we agree that there is a present shortage of technically trained men. I assume that you will accept the predictions of those who have studied the situation when they say that there is no well-defined program to reverse this trend and that this shortage probably will continue through 1960. You can if you will take one or all of the following steps to aid in correcting this situation:

(1) Convince the men who run your companies that this is a serious matter. Even though your own organization may be quite adequately staffed at the present time, the future is apt to find you shorthanded. If your principal

customers are unable to find an adequate number of engineers for their organizations your own market may be somewhat lessened. This then calls for an unselfish and broad interest to be taken in the problem by all of industry.

(2) Encourage personally any likely young men of your acquaintance to think about a career in the engineering fields.

(3) Encourage college students already enrolled in engineering curricula to continue with graduate work wherever they have the capability.

(4) Convince your company of the need for support of the operations of the private engineering colleges and for support of basic research in all of the engineering colleges. Don't let the government take over the complete responsibility for the support of basic research in these institutions.

(5) Since you are all college men, why don't you review and increase your personal contributions to the support of your colleges. They are struggling with inflation too! Perhaps I'd better stop right here because this is beginning to sound very much like the speech of a college president to an alumni gathering, isn't it?

I have tried to give you a picture of the atomic energy industry and the important part played in that industry by the electrical engineer. I have tried to make you aware of the Commission's attitude toward the participation of industrial concerns in its attempts to find useful peacetime applications for this new source of energy. I have indicated, as well, the importance to the future prosecution of the atomic energy program of a continuing and increasing supply of engineers. Finally, I have asked your assistance in taking those steps which may increase the supply of well-qualified engineering graduates in the years immediately ahead of us. This is your business and I invite you to share in some of the responsibilities for successful prosecution of its program.

REFERENCE

1. Electrical Engineering for Atomic Energy, **D. W. Cardwell.** Technical Information Branch, United States Atomic Energy Commission, Oak Ridge, Tenn., February 9, 1949.

Adjustable-Voltage Control Handles 250-Ton Crane Loads at McNary Dam

Crane controls so sensitive they can regulate the movement of a 250-ton load to within 1/32 inch were tested recently at McNary Dam by the United States Army Corps of Engineers. McNary Dam is located on the Columbia River near Umatilla, Oreg. Developed by the Westinghouse Electric Corporation, the new adjustable-voltage control has been installed on the first of two 200-ton gantry cranes built by the Judson Pacific-Murphy Corporation, Emeryville, Calif. These cranes will be used to raise and lower the 126-ton spillway gates at the dam as shown in the picture. When a gate is raised, the load on the crane approaches twice the weight of the gate, because of the downward pressure of the water rushing under it. Each crane is 60 feet long, 42 feet wide, and towers 77 feet above the top of the dam. Mounted on 16 wheels, the giant cranes move along the top of the dam on rails placed 34 feet apart.

The adjustable-voltage control embodies speed-torque characteristics that inherently cause the motor to slow down in both the hoisting and lowering cycle when the load is increased, without change in the setting of the control. The control measures the load on the motor, and adjusts the speed accordingly. The system provides a stalling torque of 200 per cent of full-load torque, thus limiting the maximum mechanical and electrical stresses.

The d-c motors for the main hoist, trolley, and bridge drives are powered through a 4-unit motor-generator set mounted in the machinery house on the main trolley atop each crane. The set converts 440-volt a-c power to direct current. For simplicity of design and operation, the d-c voltage is controlled by the generator fields rather than by resistors in series with the motors. The main hoist motor is 60 horsepower. This power, transmitted through an extensive gear train, permits a maximum speed of 4 feet per minute when the main hoist is under full load handling the spillway gates.

There is also an auxiliary trolley with hoist that can handle 15-ton loads at approximately 20 feet per minute. Counter-torque a-c control with wound-rotor motors is employed. This hoist will be used to pick up debris lodged against the upstream face of the dam, and to service the deck.

Contact Transients in Simple Electric Circuits

F. E. MARTIN   H. E. STAUSS

THE PROPER FUNCTIONING of electric contacts is of great practical importance. Much work has been one on contacts, but comparatively little has been done n types of transient phenomena occurring in inductive d-c ircuits when the circuit is broken. This oscilloscopic in- estigation covered the variation of transients occurring for fixed contact pair over a range of lumped inductance and umped capacitance values in a contact circuit. In addi- ion, effects on the transients of varying the current and the oltage impressed on the circuit were studied.

Two distinct types of transients, designated plateau and trikeover transients, examples of which are given in Figures and 2 respectively, were found. The plateau transient vas characterized by a voltage plateau at about 300 volts vhich was accompanied by a bluish-violet contact dis- harge. Strikeover transients consisted of a series of relaxa- ion oscillations; in general maximum voltages of successive trikeovers increased, as shown in Figure 2, presumably be- ause increased contact gap-length led to increased break- down voltage. Frequently a low-voltage arc occurred at he beginning of each strikeover. The rising and perfo- rated base-line (zero contact-voltage line) of the figure pro- vides evidence of such arcs. Under these conditions a greenish discharge was observed at the contacts. This ransient decreased in frequency and maximum voltage with increase in shunt capacity in the contact circuit.

Various mixed transients were observed. Plateau transi- ents were preceded frequently for short periods by strike- overs; plateau fragments were found interspersed between strikeover series, and initial plateaus often gave way to strikeovers. For relatively high currents, arcs were ob- served preceding the other transient forms.

Damped sinusoidal waves are shown terminating the voltage transients of Figures 1 and 2, and when the shunt capacity was sufficiently great the transient phenomena consisted entirely of such waves. Under the latter conditions, no discharge was seen at the gap. Apparently the waves were initiated when, as the contact gap lengthened, the voltage was inadequate to induce or sustain gap discharge.

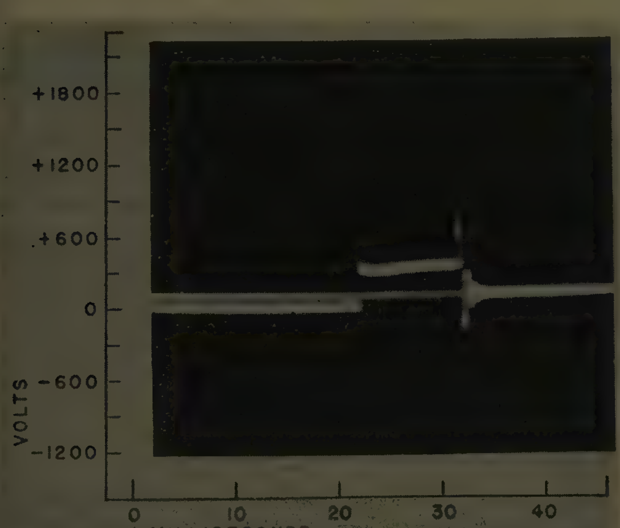

Figure 1. Typical plateau transient

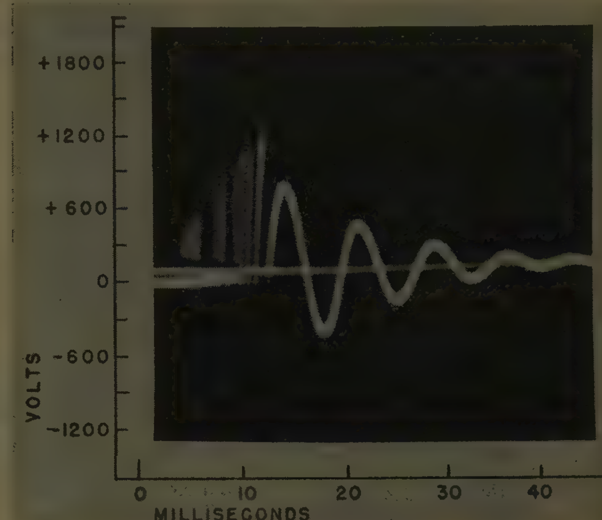

Figure 2. Typical strikeover transient and damped terminal oscillation

A transition sequence of transient types with increased circuit shunt capacities was noted under many conditions, and the following relations appeared to be true for any values of impressed voltage, current, and inductance for which plateau transients could be observed:

1. For low shunt capacities plateau transients predominated.
2. As the shunt capacity was increased plateau transients gave way to strikeover and mixed transients with the former predominating.
3. These in turn gave way for high capacities to damped phenomena similar to those terminating the other transients.

Circuit conditions which favored high-surge currents at gap breakdown were the same as those that increased the probability that voltage strikeovers would occur to the exclusion of plateaus. Gap or contact conditions also influenced the types of transient phenomena which occurred for given circuit conditions.

Digest of paper 51-48, "Contact Transients in Simple Electrical Circuits," recommended by the AIEE Committee on Basic Sciences and approved by the AIEE Technical Program Committee for presentation at the AIEE Winter General Meeting, New York, N.Y., January 22–26, 1951. Scheduled for publication in AIEE *Transactions*, volume 70, 1951.

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Fire Protection in Electric Stations

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THE OPERATION OF AN electric system today requires the highest possible reliability of service to the customer consistent with economic justification of the costs of such service.

This article deals with the fundamentals of fire protection in electric stations and discusses some fires which have occurred on the Consolidated Edison System. The most important thing is to design equipment so that the possibility of fires will be reduced to a minimum. Next in importance is to be able to extinguish such fires that do occur while they are in their early stages.

The two most important aspects of fire protection in electric generating stations—prevention by engineering design and fire fighting—are discussed in detail.

FIRE PREVENTION BY ENGINEERING DESIGN

Yard Coal Storage. Coal as it is being stored should be compacted in dense layers so as to minimize the voids which contain air and which also serve as air passages to provide oxygen for combustion. Then, as a further precaution against moisture infiltration or air penetration which would increase the probability of spontaneous ignition, the sloping sides and tops of the piles may be given a coating of heavy water gas tar or other sealing material.

Coal Bunkers. Coal bunker fires are caused when portions of the coal remain stationary for extended periods of time. Coal passages can be designed to provide a minimum of flow interruptions and stagnant areas by applying certain designs found good in practice; see Figure 1. Avoid sudden constrictions or sharp changes in direction of the coal flow. Use round cross-sectional shapes with no corners in which arching can occur. Keep all lines of flow at maximum possible angle of inclination with the horizontal. Use one vertical side in any converging section so that arching is minimized. Use permanently smooth material such as stainless steel as a lining for converging sections. Use silos rather than rectangular bunkers. Place the bunker or silo discharge opening vertically over the coal feeding equipment. Use the shortest possible chute from the bunker or silo bottom to the feeding equipment. Avoid equipment which causes intermittent coal flow such as batch-type scales.

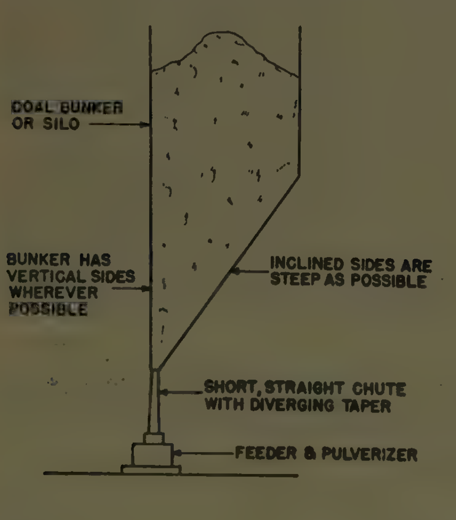

Figure 1. Schematic layout of bunker designed to maintain free flow of coal

Liquid and Gaseous Fuels. Means must be provided for shutting off the flow of fuel from a point external to the area, such as emergency shut-off valves located outside of the boiler house. Piping should be of more than adequate strength and all welded to withstand the maximum pressure which can be developed under any condition. Piping should be fabricated so as to minimize any leakage which might occur and it is necessary to locate points of possible leakage, such as valve stuffing boxes, in a safe location. Piping should be so routed as to reduce the chance, in the event of a break, that the fuel will come in contact with a source of ignition. Ignition, when starting a boiler or operating at light loads, should be continuously monitored with provisions to shut off the fuel should ignition loss or unsafe furnace conditions develop.

Lubricating Oil. Lubricating oil systems introduce a fire hazard because of the possibility of leaking oil coming in contact with hot surfaces. The auto-ignition temperature of turbine oils is from 650 degrees Fahrenheit to 700 degrees Fahrenheit. The auto-ignition temperature is the lowest temperature to which a mixture of flammable vapor and air must be heated to ignite the mixture in the absence of a spark or flame. Inlet steam temperatures in modern industrial turbines are from 750 to 1,050 degrees Fahrenheit. Oils coming in contact with surfaces at these temperatures will ignite.

It is important that all welded construction be used in the oil lines; also that any small connection for controls or gauges be of rugged construction and protected from physical damage. Fires have occurred from breakages of such slender connections.

Turbine manufacturers are locating oil reservoirs as remote from the high temperature parts of the turbine as practical. Separately driven main oil pumps may be used to accomplish this purpose.

On older flanged and bolted systems, where oil leakage is more likely to occur, the oil lines should be relocated

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way from hot steam lines and if this is not practical the area should be protected by means of a water spray system.

A 5-inch cast-iron elbow in an oil line, operating at 40 pounds per square inch pressure and connected to the oil system of the number 9 turbine generator at the Hell Gate

Figure 2. Failure of a cast-iron elbow in the lubricating oil system caused oil fire

Station, ruptured on June 28, 1943, and the oil coming in contact with the nearby high temperature steam lines (725 degrees Fahrenheit, 270-pound pressure) ignited. Figure 2 shows the broken elbow. The emergency steam-driven oil pump fed 1,500 gallons of oil through the broken elbow. The fire was extinguished in 35 minutes by sprinklers and hose streams. Severe damage was done to piping and auxiliaries in the turbine room.

Steam-Turbine-Driven Generators. Hydrogen cooling is available in new machines rated at 15 megawatts and larger. Since a hydrogen atmosphere does not support combustion, the winding insulation in modern machines will not burn following interruption of a fault in the winding. Control of hydrogen purity is essential to prevent fire and explosion. A CO_2 gas purge must be used to prevent the formation of explosive mixtures of hydrogen and air when such generators are being filled with hydrogen, or when they are being taken out of service. Portable thermal conductivity gas leak detectors are used to locate any small hydrogen leaks that may occur. The existence of a leak is also indicated by an increased use of hydrogen. When using a phase-isolated metal-clad bus, which connects to the generator terminals, a baffle insulator should be provided a few feet from the generator and vent holes also should be provided in the metal-clad housing to vent to the atmosphere any hydrogen leak coming out of the terminal bushings. These vent holes should be supervised periodically using a portable leak detector.

In air-cooled generators means may be provided for spraying fresh water in the generator housing. When the insulation on windings in such generators breaks down, arcing usually sets fire to the insulation. Perforated water pipes or steam pipes installed at both ends of the stator winding may be used. Water or steam should be admitted only after the main and field switches have been opened. To prevent accidental discharge of water or steam into the generator the final connection to the generator should be made up with a piece of hose at the time of the fire.

A stator winding fire, shown in Figure 3, was caused by a short circuit in the winding of generator number 8 at the Hudson Avenue Station on March 23, 1942. The short circuit was caused by a failure of the coil insulation in a slot. The generator and its field excitation were cleared from the bus by differential relay operation in 0.2 second. The neutral of this generator is solidly grounded. The short-circuit current persisted for about 5 seconds, which is the time required for the field to die down. Water sprays were turned on after the generator was de-energized. About one-quarter of the machine iron had to be restacked because of the burnt iron due to arcing.

Another stator winding fire occurred on January 25, 1945, on generator number 8 at the Hell Gate station due to overheated clamping details. No fire extinguishing means were used as the fire was not sustained.

Transformers. Oil-insulated transformers are the most common type and due to the flammability of the oil they present the greatest hazards.

The Consolidated Edison Company experienced two very severe transformer oil fires at the Hudson Avenue Station on March 15, 1945, and June 23, 1945. In these cases both transformers were single-phase 16.5/27.6/27.6-kv units rated at 66,667 kva each. These are autotransformers used to increase the generator voltage of two 200,000-kva machines to the bus voltage of 27,600 volts.

On March 15, *C* phase transformer of the number 8 machine experienced a pothead failure, which set fire to the oil in the main transformer tank, and which continued to burn for several hours. It is believed that the fire was caused by an electric short circuit at a 27.6-kv pothead which was cleared from the station bus by relays and circuit breakers in less than 1/2 second. In rebuilding the transformer and its vault the design was changed so that the generator cable potheads were terminated in an air-insulated housing and, through flexible connections, were connected to oil-filled bushings which are mounted in the top cover of the transformers. In addition, water spray protection was installed in each transformer vault and

Figure 3. Stator winding fire caused by short circuit in winding

made automatic so as to smother a fire before it can gain headway.

On June 23, 1945, a second failure and an oil fire occurred in a similar transformer of number 7 generator at Hudson Avenue and is shown in Figure 4. The fire was brought under control somewhat quicker and the damage due to the fire was not as great. However, it was also

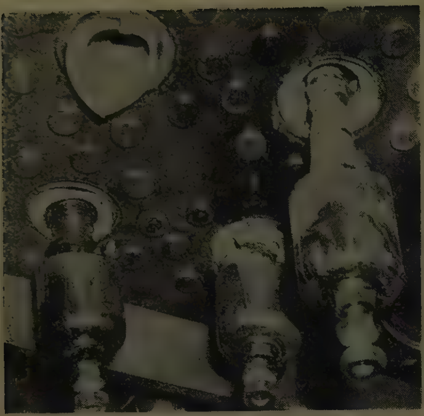


Figure 4. Transformer oil fire. Damaged cable potheads inside of 66,667-kva single-phase autotransformer

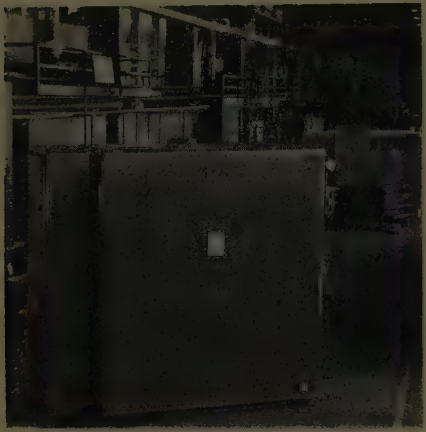


Figure 5. Sealed-tank, dry-type transformer

necessary to return this transformer to the factory for rebuilding. Needless to say, improved transformer tops and water spray protection were installed.

Important or large oil-insulated transformers should be considered carefully for protection by adequate space isolation or with fixed fire-extinguishing systems and should be surrounded with suitable brick or concrete barriers and these transformers should be placed over coarse crushed stone and the total volume of the voids should equal the volume of the oil inside the transformer.

Askarel transformers are safe from a fire hazard viewpoint, as the insulating liquid is nonflammable, but the gases which are generated during a transformer fault may be of sufficient pressure to cause rupture of the tank.

Dry-type, air-ventilated transformers have about the same fire hazard as motors of equivalent size and voltage and similar type of insulation.

The modern sealed-tank, dry-type transformers with nitrogen or other inert gas inside the tank are fireproof. The sealed tank, dry type, shown in Figure 5 with inert atmosphere inside the tank can be recommended highly.

Circuit Breakers and Switchgear. Since about 1940 fewer oil circuit breakers have been installed each year in indoor installations. In station auxiliary circuits and in 4-kv distribution substations, magnetic air-type circuit breakers generally are used.

In main generating station or high-voltage distribution substation service, use is made of air-blast power circuit breakers at 15 kv, 34.5 kv, and 69 kv. Figure 6 shows a 69-kv air circuit breaker.

A bad circuit breaker oil fire was experienced on October 26, 1949, in a 27-kv truck-type power circuit breaker at the Fifth Avenue substation, due to its being closed onto the system under out-of-phase conditions. This is illustrated in Figure 7. The circuit breaker failed to interrupt and developed pressures in the tank which caused the explosion. The substation was shut down completely and it was about nine hours later when the first bus was restored to service and the substation was able to supply power again.

The Consolidated Edison Company has now gone entirely to air and porcelain insulation in bus gear for voltages from 15 kv to 69 kv, as shown in Figure 8, and is avoiding the use of oil-filled equipment in all new major switchgear assemblies.

New Construction and Repair Work. In any modern generating station there is almost never a time when new construction or major alterations or repairs are not in progress. Many fires in these areas are caused by welders' sparks dropping on to the scaffold planks, tarpaulins, crates, and other class-*A* combustibles. Hence, special precautions should be taken to prevent sparks from falling on to combustible material.

A continuous fire watch should be maintained on all large construction jobs. At the completion of the day's work on large and small jobs, a fire watcher should make a tour of the construction area, for most fires in such locations occur at this time.

As construction progresses, the standpipe should be extended in the construction area, and hose should be attached, ready for use. If the job will last through cold weather, antifreeze extinguishers should be provided instead of the customary soda-acid type. And, of course, where oil, gasoline, or other flammable liquids are handled or stored a sufficient number of 20-pound dry chemical extinguishers should be provided.

FIRE FIGHTING

Foam Extinguishers. Chemical foam is produced by the action of a water solution of aluminum sulphate mixing with a water solution of bicarbonate of soda and a foaming agent, such as extract of licorice root, liquid soap, and so forth. The foam bubbles produced are filled with CO_2 gas.

Years ago, when nothing better was available, portable

Figure 6. 69-kv 2,000-ampere 3,500-megavolt-ampere air-blast circuit breaker

am extinguishers were installed in generating stations nd substations as protection for insulating oil fires. But day foam is being removed from such locations and is eing replaced by dry chemical, for the latter is a nonnductor and it extinguishes the fire more quickly, alough it does not prevent reignition as does foam.

Vaporizing Liquid Extinguishers. This type extinguisher, hich contains carbon tetrachloride or chlorobromoethane, is well suited for fires in exposed windings of otors or other electric apparatus. Air pocketed in the oid spaces in the windings will often resist displacement y such gases as CO_2 and aerated dry chemical, but the quid extinguishing agents can be squirted into, or they ay drip into, these voids, then evaporate and displace he air, and thus smother the fire.

Vaporizing liquid, if properly applied, is effective on nall oil fires in confined locations, but it may be prac-

Figure 7. Results of oil switch fire at a substation

ically useless on out-of-doors fires on a windy day. When vaporizing liquid is used in confined spaces gas masks hould be worn.

CO_2 Extinguishers. These are recommended particularly or switchboard fires where relays and other sensitive nstruments might be put out of service by other extinguishng agents.

Mobile Water Spray Extinguisher. The Consolidated Edison System designed and constructed a number of nobile fog outfits for use in high-tension electrical galleries. This unit consists of a 20-gallon tank of water, pressurized when called into service) by a cylinder of nitrogen at ,200 pounds per square inch with a pressure regulator nd mounted on a wheeled buggy. A 3/4-inch rubber ose is equipped with a 10-foot applicator having a spray ozzle at a 45-degree angle. This is very useful for working down a narrow gallery aisle between compartments nd directing the fog into the cell where the fire is. See Figure 9. The control valve on the applicator is equipped vith a ground wire as an added precaution in case the applicator should touch any live conductor concealed by smoke.

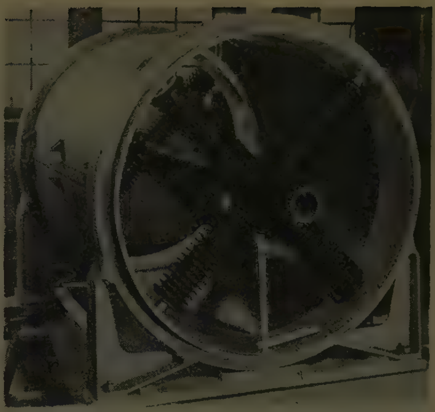


Figure 8. Section of 69-kv metal-clad isolated phase bus

Figure 9. Special 20-gallon water spray extinguisher for high-tension gallery fires

Dry Chemical Extinguishers. This relatively new kind of extinguisher is becoming increasingly popular in electric stations and substations. While this type is approved only for class-*B* and class-*C* fires, it has been found very good for blazing class-*A* fires. As the powder (about 95 to 97 per cent bicarbonate of soda) has relatively little cooling effect, it will not extinguish deep-seated fires such as those in heavy timbers or glowing embers. It will quickly "knock down" the blaze and facilitate making a rescue, closing a valve, or running for a class-*A* extinguisher, but in less than a minute the embers will cause blazing again.

Dry chemical having been found more satisfactory than foam for small- to medium-size oil fires, a large number of foam extinguishers, particularly the 40-gallon wheeled type, are being retired. One of these big units has been converted by an extinguisher manufacturer into a pressurized dry chemical extinguisher of 250 pounds' capacity, see Figure 10. The tests made thus far have proved encouraging, for this unit has ample capacity, longer range, and longer time of discharge.

Fog Nozzles. To afford protection of electric generating stations against oil fires which have reached a size beyond the ability of hand extinguishers to handle, it has been

Figure 10. 40-gallon foam extinguisher converted into 250-pound dry chemical type

found desirable to install $2^1/_2$-inch (or in some instances $1^1/_2$-inch) high-velocity fog nozzles, with low-velocity fog applicators which can be attached to them, if so desired, at strategic locations in the station. This equipment, together with two lengths of cotton rubber-lined fire hose, spanner wrenches, and so forth, should be kept in a long wooden cabinet specially constructed to accommodate them. This high-velocity fog will extinguish fires in high flash point oils, but not in low flash point liquids. It will, however, control such fires, and hence may be used. The low-velocity fog nozzle, mounted on a long applicator pipe, does extinguish both by cooling and by smothering, and thus it can be used to extinguish all oil fires of limited size. Of course, due to the metal construction, the applicator should not be used near live electric apparatus. To prevent accidental discharge of a solid stream of water from the high-velocity fog nozzle, the orifice is tapped out and a brass pipe plug screwed in. If the stream is required for a roof fire the plug can be removed readily.

Although fog should not be used intentionally on live electric apparatus, it can be done safely, even on high voltages. Unless local Fire Department regulations require $2^1/_2$-inch hose at all standpipe outlets, the $1^1/_2$-inch fog nozzle will be found most practical, for it can put out almost as much fire as the $2^1/_2$-inch fog nozzle, yet only one man is required to hold it. In other words, two men, each with a $1^1/_2$-inch fog nozzle, can put out a much larger fire than two men holding one $2^1/_2$-inch nozzle. This is important in small stations which are usually short on available manpower. Fog nozzles should not be used on unlined linen standpipe hose, for lint worn off the inside of the hose by the flowing water may clog the small orifices of the nozzle.

Foam Hose Lines. Even though water fog and dry chemical have proved very effective on small- and medium-sized oil fires, there is nothing like foam for a very large oil fire. This foam may be supplied either by underground piping which leads to mixing chambers at the top of the tank or by portable hose lines. Ordinarily chemical foam is used for this purpose.

Portable apparatus is also available for producing mechanical foam. This is a liquid foam solution (like liquid soap) which is drawn into the hose nozzle and mixed with the water. Air is also sucked in to aerate the bubbles. Each type of foam has its advantages and limitations. For instance, chemical foam is heavier, more stable, and will adhere better to vertical surfaces, but each line usually requires four men to operate it—two at the nozzle and two dumping foam powder into the foam generator hopper. On the other hand, mechanical air foam will flow more freely across the surface of the burning oil and will work its way around obstructions, and only one man, or possibly two, is required to handle the hose line.

Foam of either type can be discharged through a special fog nozzle. This gives the great heat absorption advantage of fog, and in addition a foam blanket forms on the surface of the burning oil and prevents its reignition.

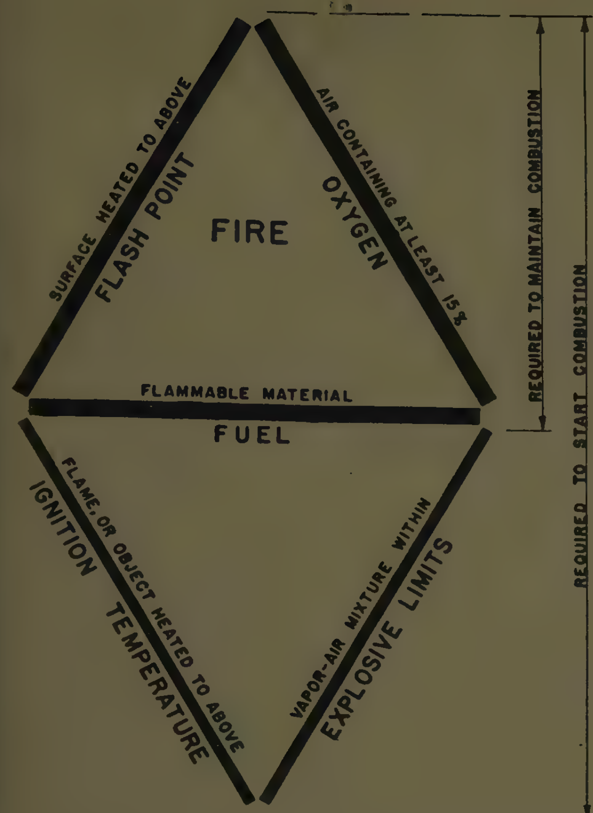
Oil Fires. Oil fires in generating stations are no different from those occurring elsewhere, except for the quantities involved. Those in protected areas will be handled automatically or manually by the spray, CO_2, or chemical foam system which has been installed for that purpose. Those in other, unprotected locations can best be handled by dry chemical extinguishers, or by fog or foam hose lines, or by any combination of these extinguishing agents.

Gas Fires. One very important rule is: Never extinguish a gas fire, unless by so doing you can gain access to the shut-off valve and thereby stop the flow of the gas. This rule applies to fires in acetylene cylinders or hoses, as well as in the large piping used to supply natural gas to the boilers.

Electric Manhole Fires. Dry chemical extinguishes the fire most quickly but, like CO_2, it has relatively little heat absorption ability, so if the metal of the transformer remains hot there is a possibility of reignition. Also, dry chemical leaves some mess inside the manhole, not as bad as foam, but enough to cause an objectionable dust cloud in the neighborhood when it is displaced from the manhole by a jet from an air hose. Some degree of success has been had by throwing a dozen or so of the small glass bombs containing carbon tetrachloride into the manhole. Regardless of the kind of extinguishing agent used, the manhole must be purged and tested before anyone is allowed to enter it.

Fire School. To train the fire brigade members in the proper technique for extinguishing all types and sizes of fires, it is desirable to organize and equip a fire school where the men can receive the necessary instruction and experience on actual fires, Figure 11. Lectures should be

Figure 11. High-velocity fog directed at target energized at 27 kv



Material	Flash Point, Degrees Fahrenheit	Ignition Temperature, Degrees Fahrenheit	Explosive Limits, Per Cent	Vapor Density
Hydrogen	Gas	1,085	4.1–74.2	0.069
Illuminating gas	Gas	1,094	5.3–31.0	
Propane	Gas	871	2.4– 9.5	1.56
Butane	Gas	806	1.6– 8.5	2.05
Acetylene	Gas	635	2.5–80.0	0.91
Carbon monoxide	Gas	1,204	12.5–74.0	0.97
Ether	−49	356	1.8–36.5	2.56
Gasoline	−45	495	1.3– 6.0	3.00 to 4.00
Carbon disulphide	−22	212	1.0–50.0	2.64
Acetone	0	1,000	2.5–12.8	2.00
Benzine	0		1.1– 4.8	4.48
Benzol	12	1,000	1.5– 8.0	0.88
Wood alcohol	52	800	6.0–36.5	1.11
Grain alcohol	55	700	3.5–19.0	1.59
Turpentine	95	464	0.8–	
Cleaning solvents	100 to 110	450	1.1– 6.0	
Naphtha	100 to 110	900 to 950		
Kerosene	100 to 165	490		
Fuel oil #1	100 to 165	490		
#2	100 to 190	494		
#3	110 to 230	498		
#4	150 up	505		
#5	130 up			
#6	150 up	765		
Transil oil	295			
Turbine oil	500	700		

Figure 12. Elements of combustion

given on such subjects as various types of extinguishers, the use of fog and fog nozzles, and elements of combustion, Figure 12.

Co-operate with the city fire department by inviting the officers of the nearest fire company to visit the station and show them all the hazards so that they can avoid them if called to a fire in the plant. Have the fire brigade drill in the presence of the chief and you will find the fire department officers very co-operative. Then, if called to a fire in the station, the firemen will be receptive to any advice or suggestions you may have to offer them.

CONCLUSIONS

1. Coal bunker fires are caused when portions of the coal remain stationary for extended periods of time. The occurrence of fires can be eliminated by careful design which assures no stagnant areas and by frequently emptying the bunkers.

2. Liquid and gaseous fuel piping must be of more than adequate strength and all welded to withstand the maximum pressure which can be developed under any condition. Piping should be so routed as to reduce the chance, in the event of a break, that the fuel will come in contact with a source of ignition, such as a hot surface. Means must be provided for shutting off the fuel from a point external to the area.

Lubricating oil systems also introduce a fire hazard because of the possibility of leaking oil coming in contact with hot surfaces. All welded construction should be used and small connections for controls or gauges must be of rugged construction and protected from physical damage. The oil lines should be located at a reasonable distance away from hot surfaces.

3. Fires in oil-insulated transformers are generally extremely intense and, therefore, it is important that they be located carefully. Important or large oil-insulated transformers should be considered for fixed water spray fire extinguishing systems.

Askarel transformers are safe from a fire hazard viewpoint, as the insulating liquid is nonflammable, but the gases which are generated during a transformer fault may be of sufficient pressure to cause rupture of the tank.

The modern sealed-tank, dry-type transformers with nitrogen or other inert gas inside the tank are fireproof. The sealed tank, dry type, with inert atmosphere inside the tank can be recommended highly.

4. To reduce the fire hazard from oil-filled equipment in inside plant locations magnetic air-type or air-blast circuit breakers should be used. For the same reason the use of totally enclosed metal-clad bus and switching equipment is recommended.

5. During major construction or repair work many fires are caused by welders' sparks dropping on to planks, tarpaulins, crates, and so forth. Special precautions must be taken to prevent sparks from falling on to combustible material.

6. The mobile water spray extinguisher is very effective in electrical gallery fires.

7. The dry chemical extinguisher is the nearest approach to an all-around hand extinguisher which is commercially available for use on small- to medium-size fires in electric stations.

8. High-velocity water fog from a $1^{1}/_{2}$-inch or $2^{1}/_{2}$-inch fire hose is the best all-purpose heavy-duty portable fire equipment for use on medium- to large-size fires in power plants.

9. In order for any electric station to provide its own fire protection, it is necessary not only to install proper extinguishing equipment but also to train personnel in its selection and use. Every electric company should organize its own fire school where practice can be had on actual fires under simulated station operating conditions.

Experiences with 230 Kv on the Bonneville System

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SOME PAST PRACTICES in the high-voltage transmission of power have been more conservative than proved necessary. Liberalized practices put into effect on the 230-kv system of the Bonneville Power Administration have resulted in sizable annual savings.

It is present Bonneville practice to use 14 suspension insulators for 230 kv on steel structures and 12 on wood-pole lines. Since lines are not protected with ground wires, insulation levels are not determined by lightning but rather by switching surges, safety practices, and maintaining service with broken units. Four steel towers with 11 units have operated satisfactorily for six years. Insulation levels could be reduced to 10 units on wood and 12 on steel, but these levels violate the National Electric Safety Code (NESC). The NESC has been adopted by some states as law, and for insterstate transmission lines it is economical to adhere to a common design. On lines equipped with ground wires, insulation levels probably should be determined by lightning flashovers and may well be higher than on unprotected lines. Radial counterpoise is used on some double-circuit towers to reduce the number of double-circuit outages that occur from tower hits.

Adherence to the NESC involves higher costs without contributing to personnel safety. Steel structures must be designed to obtain specified clearances with a 45-degree swing of the insulator string, but wood-pole structures need be designed only for a 30-degree swing. The hazard to personnel does not appear to be greater when working on steel structures than when working on wood poles. Maintenance is accomplished with lines energized whenever possible. When insulators swing as much as 30 degrees, maintenance is conducted only in emergencies when lines are out of service.

A maximum working tension of 40 per cent of the ultimate strength is used in sagging conductors. These lower tensions permit economic structure designs and keep vibration to a minimum. Steel-reinforced aluminum cable conductors are now the predominating type. All suspension points are equipped with armor rods.

Earlier structures could withstand stresses due to broken conductors, but experience indicates only a small degree of risk from this hazard. New light steel tower and wood-pole H-frame designs supplement heavier designs previously used. Wood-pole structures more recently put into use have 20-foot conductor separation permitting use of a 1-piece crossarm.

The 230-kv wood-pole structures are susceptible to pole fires which usually occur on guyed structures. Large washers or gain plates making good surface contact to both crossarm and pole reduce the danger of pole fires.

Counters on 230-kv lightning arresters in lightning areas have never operated. The counters were tested and found to be satisfactory, yet lightning hits have occurred to conductors just beyond the 1-mile protective ground wire adjacent to major substations.

The greatest factor effecting the magnitude of a traveling wave reaching a station bus from a mile or more away is the number of lines terminating on the bus. When lightning strikes a conductor on a steel-tower line, flashover usually occurs at the nearest towers in both directions from the hit. After flashover, the potential remaining on the line is a function of the tower current and the footing resistance. The usual wave traveling toward a station consists of an initial high overvoltage, short-time surge followed by a longer tailed wave of lower magnitude. A high rate of attenuation reduces the initial surge so that it is not dangerous when it reaches the station bus. If more than two lines terminate on the bus, the voltage is reduced further due to the lower equivalent surge impedance, so that in stations containing a multiplicity of lines traveling waves initiated a mile or more away do not reach the station with enough voltage to cause lightning arresters to operate. If a station is protected from direct strokes for one mile and where at least four lines terminate on the bus, the probability of lightning-arrester operation is remote. The same effective result is obtained for stations protected with two miles of ground wire with at least three lines on the bus.

The 1,050-kv insulation level for 230-kv transformers and circuit breakers was reduced to 900 kv in 1948, effecting a reduction of 14 per cent in insulation level and in cost. This level has been reduced further recently to 825 kv. A still lower level can be protected from surge voltages, but some manufacturers have indicated that this is the minimum insulation level necessary to withstand power-frequency stresses. It is suggested that a power-frequency accelerated life test would be more appropriate than a surge test to determine the power-frequency limitations of major insulation.

Rapid growth necessitates increased transmission capability. One method would be to increase the voltage of existing lines by use of autotransformers. Early tower designs and insulation levels on Bonneville Power Administration 230-kv lines are considered adequate for operation up to 300 kv. Another method is to insert a relatively small and inexpensive 2-winding transformer between the neutral and ground of transformers now in service which have a 1,050-kv basic impulse insulation level, and with the neutral insulated for 66 kv a basic impulse insulation level of 1,050 is satisfactory for voltages up to 295 kv.

Transmission capability also can be increased by the use of series capacitors. An installation of this type is now in service on the Bonneville system.

Digest of paper 51-292, "Experiences with 230 Kv on the System of the Bonneville Power Administration," recommended by the AIEE Committee on Transmission and Distribution and approved by the AIEE Technical Program Committee for presentation at the AIEE Pacific General Meeting, Portland, Oreg., August 20–23, 1951. Not scheduled for publication in AIEE *Transactions*.

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Statistical Methods in a Utility

E. L. HARTMAN

Statistical engineering has many applications useful to the utility engineer who must process large amounts of data. How some problems were solved by one large utility using these techniques, and some possible future applications, are presented here.

N AN ORGANIZATION such as The Hydro-Electric Power Commission of ntario, there is bound to be a eat deal of data collected d processed. Wherever ch a situation exists, statisians are involved. There ve been many unkind remarks passed about statisticians, tended to throw doubt on their intelligence, their veracity, d even their ancestry. In the popular mind they are rhaps further subdivided into two classes—those who llect dry figures for the census bureau or the insurance mpanies, and those who inflict the study of "Least uares" on student engineers. This latter class, at least, s in recent years been granted some measure of reectability and engineers are finding much of interest and lue in statistical analysis as an aid in the practice of gineering. It is this aspect of statistics—statistical gineering—that will be discussed. It is not the intention treat in this article any details of technique or specialized plication. Instead, it is the aim to illustrate for the initiated the general applicability of statistical methods examples of typical problems which have been dealt ith in the Commission, and in its Research Division.

For those unfamiliar with statistical terms it may be elpful to describe in simple form some of the guiding rinciples which underlie all the different aspects of statiscal methods. In one word, the basic theme is "variation." o take a very simple example, suppose two sets of data re taken from two samples of 10 individuals each. If the verages were greatly different and each sample uniform itself, it would immediately appear that the two samples ere different. If the averages were closer together, or the variations within the samples were high, so that me overlapping of individuals occurred, it would be less rtain that the two samples or the processes which proced them were different. A statistical engineer could aluate the risk in making a decision that the two processes r products are, in fact, different, and what the probable ifference is. The analyst would first cut a "yardstick," ased on the variation in the two samples, and then use at yardstick to evaluate the difference between the mple averages. The procedure used to calculate this ardstick is a matter of technique but the "yardstick hilosophy" is important to every engineer. Balanced dgment of data is possible only when there is some ppreciation of the order of magnitude of the variation ue to testing errors, chance selection of the sample, and ther factors. To some extent this appreciation is deeloped with experience but statistical analysis is a more eliable and more immediate aid.

Some applications of statistical methods are already familiar to engineers. The last war saw a great increase in the use of statistical quality control in industrial plants to aid production men in controlling product quality during manufacture. Statistical sampling schemes were widely used in the acceptance of materials, both by processing industries and by the armed forces. These techniques have become familiar through the wide distribution of such books as the "American Society for Testing Materials Manual on Quality Control of Materials,"[1] based on the original work by Dr. Shewhart, and "Sampling Inspection Tables."[2]

Other terms which denote phases of statistical methods less familiar to the engineer are: tests of significance, analysis of variance and covariance, design of experiments, and regression and correlation analysis. Once one has absorbed the yardstick philosophy—usually met first by engineers in control chart procedures—these other phases become less terrifying and their application more apparent.

APPLICATION OF CONTROL CHART METHODS

THE APPLICATION of statistical methods in a public utility such as The Hydro-Electric Power Commission of Ontario is, of course, somewhat different from the application in manufacturing plants. The Commission manufactures for sale only one product—kilowatts—and control charts are not applicable at any stage of their production; nor is this product subject to acceptance sampling by the consumer. The Commission produces great quantities of concrete for use in dams, tunnels, and buildings, and statistical methods have been applied to control concrete quality with some success. For the most part, however, the Commission is in the position of a consumer purchasing a large range of items in quantity.

Because the Commission generates most of its power by hydraulic means rather than steam, it has a huge investment in concrete structures. Quality of this concrete and of the materials which go into it is therefore of prime importance and cement was first turned to as an item for study by statistical methods. It is purchased from a number of different sources throughout the country and at each mill a resident inspector samples the product during manufacture. Although the sampling is done during manufacture, there is no thought of control of the process by

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these samples because of the great time lag before test results are known. In a sense this is acceptance sampling, for all cement must be held in storage until it is approved by the Commission on the basis of tests carried out by the Research Division. Some of these test results can be obtained quickly; others, such as strength and chemical analysis, take time. To make an early decision on the suitability of the material, it is helpful, then, to be aware of any trends which may be developing with time.

Trends are most apparent if illustrated graphically, so the control chart method was adopted for analyzing cement tests of strength, chemical composition, and a quantitative measure of soundness. Control limits were established for these charts to indicate the extent of the variation which may be expected among future samples, and which may be considered as the normal chance variation of such samples from such a process. These limits are based on the past performance of similar samples and illustrate the yardstick philosophy referred to previously. As long as test results are randomly distributed between these limits it is assumed that the process is unchanging and the product unchanged from that which prevailed during the period from which the limits were calculated. However, the appearance of a test value outside the limits, or a number of consecutive values in ascending or descending order, or even a certain number of consecutive points on the same side of the average, is an indication that something has changed and needs investigation.

In addition to such charts, which indicate mainly the variations in product quality, it is useful to maintain charts showing the variability among identical specimens from the same sample. Again the yardstick principle is used to establish limits for this variation, which is a function mainly of testing. In this case any value of range-within-sample which exceeds the control limit is taken as an indication of need for investigation of the testing procedure itself. These charts are not revolutionary in concept; they represent rather a fairly obvious common-sense approach to recording and simultaneously analyzing data. Their maintenance adds little to the duties of the technician or clerk and their ready interpretation saves considerable time for the engineer who must approve the material.

In four years of operation these charts have proved their worth many times. They have focused attention on testing procedure and equipment and initiated several test programs in these fields. The programs were statistically designed and analyzed and resulted in recommendations involving such varied factors as change in work schedule, purchase of new equipment, and transfer of personnel to other duties. In addition to these benefits the charts have made it possible to reduce the amount of routine testing without an increased risk. This has amounted to a tidy saving in inspection costs on the last 2,500,000 barrels of cement purchased.

The principle of using charts for analyzing data and determining trends has been adopted also in the production of concrete at the job site. Here again the time-for-test factor makes it impossible to control the product by mathematics or graphs alone, but long-term trends, so important in concrete control, may best be detected graphically. Perhaps the psychological aspect of these charts is of equal importance; there is less chance of the process being over-corrected if the inspector can see that test results are still falling within the band defining chance variation. These charts are a slightly modified form of the charts most commonly found in industrial practice. They record the test strength of a single specimen at 7-day age and the average-and-range of two specimens at 28-day age. Because seasonal and other factors influence the strength level, control limits for test points are plotted about the running average and are themselves based on the variation indicated by the successive difference between test points. The human element is important in this type of test and each inspector is represented by a different symbol on the chart, thus supplying an additional, quantitative factor in evaluating an individual's work. From these charts a coefficient of control is calculated to compare performance on various jobs and to compare with other organizations doing similar work. The charts themselves form a valuable part of the job history for the records.

STATISTICAL APPROACH TO SAMPLING

Although some of the Commission's equipment is purchased in single units, many items such as wire, line hardware, poles, and lamps are purchased repeatedly and in lot quantities. This is a fertile field for the application of statistical methods, both in specification and in acceptance sampling. Much more can be done to make specifications statistically sound. In many cases analysis of data in conjunction with normal engineering knowledge would result in a better choice of tolerance limits and perhaps even in performance level. With large quantities of material, inspection procedure becomes an important item of cost. The purchaser naturally wishes to be sure that the material supplied does meet the requirements of his specification. The size of the sample to be inspected or tested and the tolerance limits for these sample pieces as differentiated from the design tolerances can be evaluated properly by statistical means. Some schemes, based on the proportion of material outside design tolerance, are probably familiar to many—they have been widely used by industry. There are, however, other systems of sampling which allow very much smaller sample sizes if certain conditions exist. These are much less familiar but deserve increasing attention, particularly by those industries which buy repeatedly from the same source of supply. All of these plans may be adapted to yield a known degree of protection for individual lots of material or for average quality over a period of time; they may be adapted to sentence material based on a given sample size or a number of successive sample sizes to furnish the psychological effect of "another chance." There is no doubt that many inspection dollars are spent which could be saved by an appreciation of the potentialities of such schemes.

One small example may be worth quoting. Long-life lamps are purchased by the Commission and marketed under its own trademark. A national specification for lamps exists which defines the sample size as an arbitrary 5 per cent of the lot for testing efficiency. By analysis of the data from this test it was found that the producer

lized a system of lot processing which resulted in good iformity within a lot, with possible significant differences tween lots. This process was ideally suited to a variables-pe sampling scheme using a small, constant sample size th acceptance limits set inside the national specification nits by an amount determined from the within-lot riability. This sampling procedure has been in opera-on for some time and has reduced testing in this phase of spection by about 85 per cent without sacrificing the ility to detect unsatisfactory quality.

There are many applications of statistical methods hich can be lumped together under the general term nalysis of data." Particularly in the Research Division the Commission, where much of the activity is testing, e interpretation of test results, and their presentation r reports is a daily concern. For instance, the question ay be whether one make of flashlight battery is better an another, based on tests of a small sample. The data ay consist of five values for each of three makes—the verages are not the same, but are the differences significant view of the variation that exists? The yardstick principle elds the answer quickly and allows rating of the products ith a definite degree of assurance. Some other typical pplications have been in evaluating types of line hardware, amps, joints, and so forth; the effect of different treat-ents or test conditions on the observed strength of rope; e quality and uniformity of steel strand from various ppliers; the relative effect of different wood preservatives, re retardant paints and chemicals, and so forth. There re innumerable examples of this type of application here the basic question is "How significant is this observed ifference or is it due solely to chance selection of the amples?" Other problems involve the validity of the elationship of one characteristic to another: "How good is nondestructive test as an indicator of some property hich can only be measured directly by a destructive est?" Once again statistical procedures are employed yield an answer that reads, say, "X hardness is equivalent a strength between Y_1 and Y_2" with a known probability f being right.

Other problems are more complex—they may involve a umber of factors which contribute in unknown proportions some end result which is desirable or undesirable. Is it ossible with a minimum of experimental work to resolve ese factors and show their effects in their true light? gain statistical methods may be called on to design an xperimental program and analyze the data to this end. s is to be expected, these methods are somewhat more omplex than those used for control, but basically they rely n the yardstick principle.

In textbooks this yardstick is referred to as the "effect of hance." Suppose a material produced under the opti-num conditions is sampled for uniformity. Even in this roduct there will be variation if the measuring technique sufficiently refined. This is variation due to chance alone nd may be estimated by analysis of the sample data. uppose a definite cause of variation is introduced and gain the product is sampled and another estimate of the ariability is computed. This estimate is larger than the rst and the ratio of the two estimates, properly weighted to take account of sample size, serves as an indicator of the extra variation introduced. If an experiment is carried out at different levels of the unknown factor, for example, testing lamp life under different conditions of voltage, it is possible to evaluate the added effect of changing this factor by comparison with performance when the effect is not operating. This is the principle employed in designing an experiment. However, instead of introducing one source of variation at a time and determining its effect alone, it is possible and more economical to introduce all suspected causes at once in a pattern which makes it possible to unscramble the whole into its component parts and at the same time evaluate the interaction effects of different variables in combination—such as temperature and pressure in a chemistry experiment.

This procedure is widely applicable in engineering work—on a plant scale as well as in the laboratory. Here is an example which may appeal to the utility men. The control of brush along the Commission's right-of-way is an important economic problem and methods other than manual brushing have been sought for some time. In 1949 an investigation of chemical herbicides for brush control was undertaken. There were many factors whose effects had to be determined and because of the time element it was essential that as many as possible be evaluated simultaneously. Accordingly, a series of field trials was initiated to demonstrate the effectiveness of the different herbicides available, the effect of size of plant, the sus-ceptibility of different species, and the effect of time-of-spraying on the over-all efficiency. The amount of data resulting from this program was quite formidable but the information gained has repaid the time spent on planning and analyzing. Within a period of two years sufficient confidence was established in chemical brush control to justify larger expenditures on equipment for full-scale trials. Other investigations on a fairly large scale have included studies of methods for sampling and testing insulating oil, inter-laboratory programs on cement testing and concrete testing, and a long-term experiment to evalu-ate the effect of various compounds as joint filler material.

There are other fields in which statistical methods may be employed by a power company. The broad field of surveys by sampling methods has great possibilities. Such methods are expected to answer questions in meter and fuse problems, utilization of off-peak power, and perhaps even rate structure. The information so gained may yield economical yardsticks for load forecasting and system planning—both vitally important to the utilities.

The statistical methods for collection and analysis of data as used by the Commission's Operation and Con-sumer Service Divisions would be another story. This article has been an attempt to point out only that engineer-ing applications for statistical methods have been found in at least one phase of this utility's over-all activities, and that they are a worth-while part of control, testing, and research.

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Blocking-Tube Oscillator Design for Television Receivers

A. F. GIORDANO

Presented from the viewpoint of the circuit designer, this article discusses the factors which enter into the development of an operating circuit with the desired performance. Emphasis is on the vertical deflection blocking oscillator, but the principles also apply to the horizontal oscillator.

THE BLOCKING-tube oscillator as used in the television receiver is analogous to a synchronized low-impedance switch which is made to open and close periodically in a saw-generating circuit in order to produce the voltage waveform necessary to drive the output deflection amplifier.

Illustrated in Figure 1 is a basic grid-cathode coupled blocking oscillator circuit with typical parameters for a 60-cycle repetition rate and approximately 200-microsecond pulse width. Figure 2 illustrates the voltage and current waveforms. The polarity of the transformer is such that an increasing current in the primary induces a positive voltage at the grid side of the secondary. For simplicity, assume that capacitor C_1 has an initial charge such that the grid is below cutoff for the value of E_{bb}, and is discharging toward ground potential at a rate determined by the time constant R_1C_1. Since the plate current is zero, the cathode is also at ground potential; therefore, the actual grid-to-cathode voltage, V_g, is approaching zero asymptotically. When V_g becomes slightly less than cutoff, plate current flows into the primary winding and induces a positive voltage at the grid side of the secondary. At first there is no grid current flowing through C_1 to change its charge, so this secondary voltage appears on the grid. With a step-up into the secondary, the grid potential is increasing faster than the cathode, and the grid-to-cathode voltage, V_g, becomes less negative. The grid-plate transconductance, G_m, at this time is high and the primary current increases and causes a further increase in V_g. Because of the amplification of the triode the feedback gain is much greater than 1 and regeneration exists. The plate current and grid voltage rise very rapidly, at a rate limited only by the leakage inductance of the transformer. When V_g passes through zero and becomes positive, current flows to the grid and the transformer becomes heavily loaded. Because of the large value of C_1, the drop across it is small during the rapid rise of the grid voltage. The increase of plate current through the plate load resistance, R_2, decreases the plate-to-cathode voltage, V_p, and consequently the G_m of the triode drops. At the peak of the pulse the plate voltage almost equals the grid voltage so that the amplification is close to zero and power fed back cannot supply the losses.

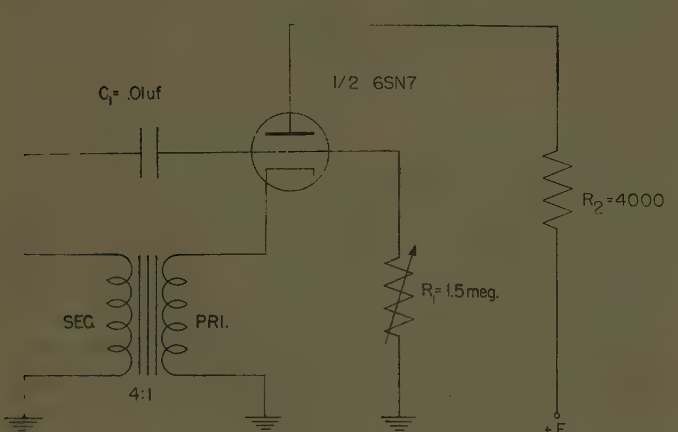

Figure 1. Circuit of the basic grid-cathode coupled blocking oscillator. Constants shown are for 60-cycle repetition rate and 200-microsecond pulse width

Therefore, the energy stored as charge in the distributed capacitance of the transformer and the magnetic fields associated with the leakage inductance and magnetizing inductance cannot increase any further, and it starts to decrease. The induced voltage on the secondary therefore reverses. Because of the heavy grid loading the currents decrease slowly. As the difference in voltage between plate and cathode increases, G_m increases and delays the decrease in currents. The loss of grid voltage because of the charging of C_1 contributes in decreasing V_g.

Not until V_g falls slightly below zero, so that grid current ceases, does the grid go sharply negative. The grid loading has been removed and the accelerated return of the stored energy from the fields of the unloaded transformer causes an oscillatory negative backswing dampened only by the transformer losses. The large negative charge on C_1 adds to this oscillatory backswing, the two effects swinging the grid sharply beyond cutoff. After the transformer oscillation has ceased, the grid capacitor discharges relatively gradually through the grid leak, R_1, until cutoff is reached when the cycle repeats, resulting in a "free-running" blocking oscillator. Because of the nature of the grid pulse, this type of blocking oscillator is usually referred to as operating in the exponential mode.

This may be an opportune time to point out a charac-

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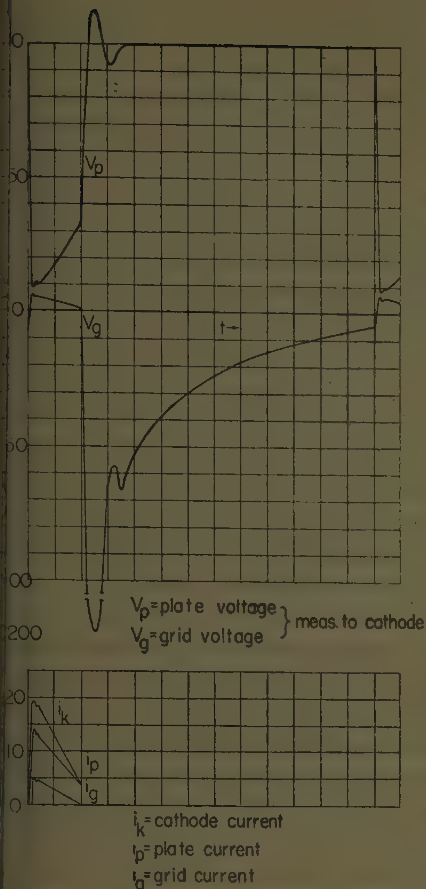


Figure 2 (left). Waveforms for the basic grid-cathode coupled blocking oscillator

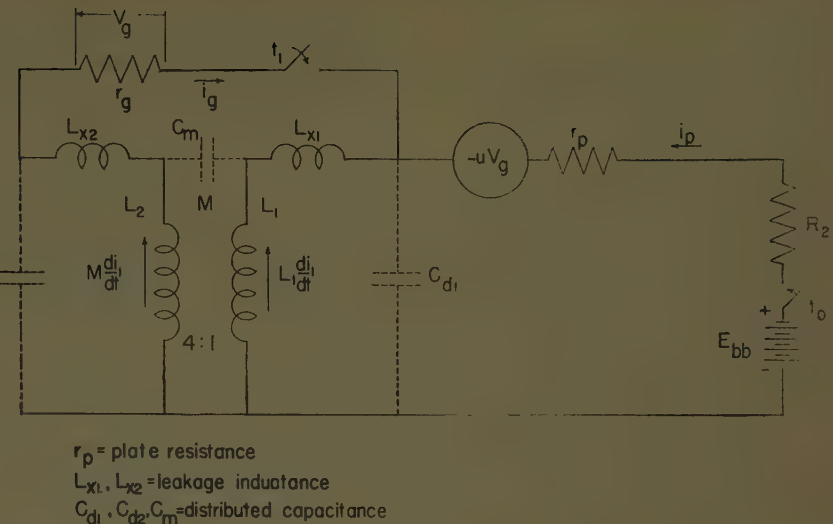


Figure 3. Equivalent circuit from start of oscillator pulse at E_{co} to equilibrium at the peak of the grid voltage

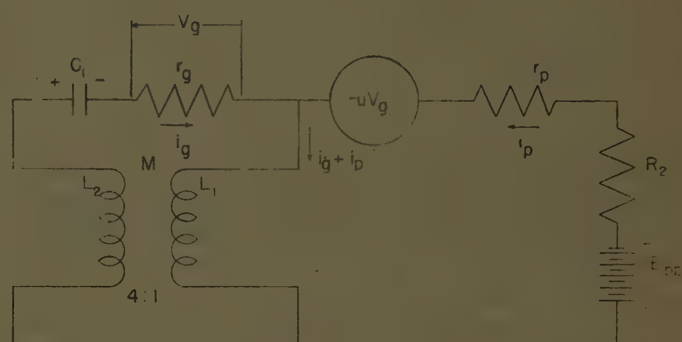


Figure 4. Equivalent circuit during the top of the oscillator pulse to zero grid voltage

eristic of the blocking-tube oscillator which will be discussed in more detail later in connection with synchronization and interlace. A positive pulse applied to the grid before the "free-running" start of the oscillator pulse so as to carry the grid above cutoff earlier will initiate regeneration prematurely. This principle is utilized to achieve synchronization. Less well known is the fact that the grid pulse may be terminated prematurely by a negative pulse on the grid or a negative pulse on the plate occurring near the end of the oscillator pulse and of sufficient magnitude to drive the grid to zero. The significance of this property of the blocking-tube oscillator will be evident later in discussing interlace.

QUANTITATIVE ANALYSIS OF THE CYCLE

THE BLOCKING-TUBE OSCILLATOR cycle may be divided into two major parts. The first part is the period during which the grid is below cutoff and the grid capacitor C_1 is freely discharging exponentially through R_1. This portion of the cycle is readily analyzed quantitatively. The repetition rate of the pulse is controlled by R_1C_1, the maximum initial charge E_o on C_1 and the cutoff voltage, E_{co}. The period may be expressed approximately as being equal to $2.3R_1C_1 \log (E_o/E_{co})$, neglecting the pulse time.

The second major portion of the cycle, the duration of the positive grid pulse, is much more complex. Because of the nonlinearity of the tube parameters and transformer inductance, it is difficult to analyze the blocking oscillator mathematically during this period. To the author's knowledge, a rigorous solution has not yet been given, but the effect of the various circuit parameters on the pulse shape can be indicated by approximately equivalent circuits.

It is best to analyze what occurs during the pulse by breaking it up into four phases: (1) from initiation of regenerative action at cutoff to zero bias; (2) beginning of grid current to point of equilibrium at maximum plate current and grid voltage; (3) from equilibrium to zero grid voltage; and (4) from zero grid voltage to end of transformer backswing.

The equivalent circuits are shown in Figures 3 and 4. In Figure 3 from $t=0$ to time t_1 (instant of grid conduction), the grid to cathode resistance, r_g, is effectively disconnected. During this period of rapidly increasing voltages, the primary and secondary inductances represent high impedances and most of the current flows into distributed capacitance and the leakage inductance. Because of the step-up into the grid, the effective grid voltage, V_g, is equal to the secondary voltage minus the primary voltage. Thus, it is necessary to have a turns ratio greater than 1 to drive the grid above the cathode. The flow of plate current through the plate resistance, r_p, and R_2, results in a rapid decrease in plate voltage and in G_m. At t_1, r_g is connected in the circuit, loading the transformer. At equilibrium, the peak of the grid pulse, the grid and plate

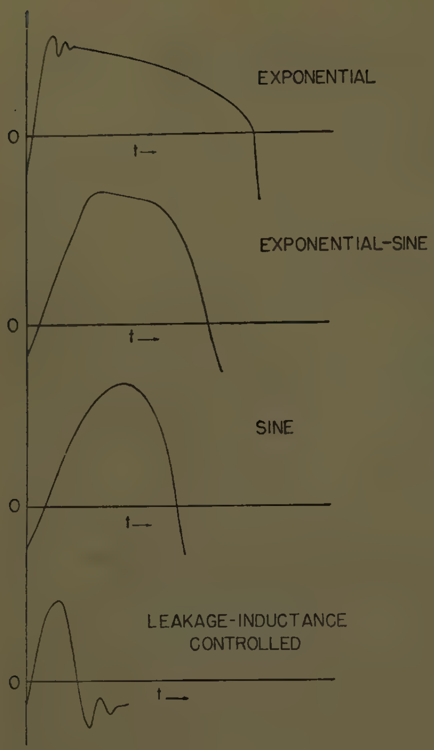


Figure 5. Modes of operation of blocking oscillator during the pulse interval

voltages approach each other and the tube is momentarily behaving like a diode with zero amplification. It can be seen that with a smaller value of R_2 the plate voltage will decrease less and equilibrium will occur later. Then the grid voltage will rise higher before the diode condition is reached. Because of the delay in attaining equilibrium, the charge on C_1 and the magnetizing current become appreciable and subtract from V_g as the top portion of the pulse is reached. The leading edge will resemble the start of a sine wave, but the peak is clipped at equilibrium. This is referred to as the exponential sine mode shown in Figure 5.

If R_2 is reduced to zero, and C_1 and magnetizing inductance are small, the grid voltage will decrease rapidly after the peak and the grid waveform will resemble that of a half-cycle sine wave. This is referred to as the sine mode shown in Figure 5.

Also illustrated is the leakage inductance mode where the pulse is determined primarily by the leakage inductance and goes negative after the first half-cycle of oscillation.

In the equivalent circuit after equilibrium, the currents and voltages are changing slowly and the circuit may be represented by Figure 4. The grid current is flowing in the primary winding in the same direction as the plate current and they are decreasing. The voltages of induction have reversed their polarities after equilibrium. The turns ratio, primary inductance, and C_1 influence the decay of V_g. The pulse width increases with L_1, turns ratio, and C_1. The plate load resistance essentially introduces degeneration and increases the pulse width.

After termination of the pulse, the negative undershoot is the oscillatory discharge of the magnetizing field and the distributed capacity, and its magnitude is influenced by the Q of the transformer. The voltage across the grid capacitor C_1 is equal to $1/C_1 \int i_g dt$ taken over the pulse interval.

Illustrated in Figure 6 are various connections of the blocking oscillator. In the plate-grid coupled circuit, the degenerative effect of the cathode winding does not exist. The polarity of the transformer is such that an increase in primary current induces a positive grid voltage. For a high plate pulse amplitude, a step-down of primary to secondary voltage may be desirable, whereas in the cathode-grid coupled circuit previously discussed, there must always be a step-up due to the degenerative effect of the cathode winding. Also shown is the plate to cathode and plate-grid-cathode coupled oscillators. The circuit selected depends upon the type of performance desired. Some of the merits of these alternate forms will be mentioned later.

In the television receiver employing magnetic deflection, the vertical amplifier must be driven with a negative-peaked sawtooth waveform. Figure 7 shows a conventional modified blocking oscillator which acts as a low impedance switch across R_2C_2. During the part of the cycle when the blocking oscillator tube is cut off, C_2 charges through R_3 towards the supply voltage. When the oscillator conducts during the pulse, C_2 is discharged. Essentially, the circuit differs from the previously discussed basic oscillator in that the voltage E_{bb} now has a sawtooth component superimposed on it which is equal to the saw voltage across C_2. The effect of the capacitor C_2 on the pulse width is roughly proportional to the percentage of saw on E_{bb}. Increasing saw decreases the pulse width.

Figure 8 illustrates the manner in which the output waveform is generated. To simplify matters, R_g represents the effective blocking oscillator resistance during conduction. Time constant R_3C_2 should be large compared to the scanning period t_2 to obtain a linearily increasing saw voltage. The amplitude of the output saw voltage is controlled by the variable resistor R_3. The negative-going pulse in the output is generated in R_2 by the plate

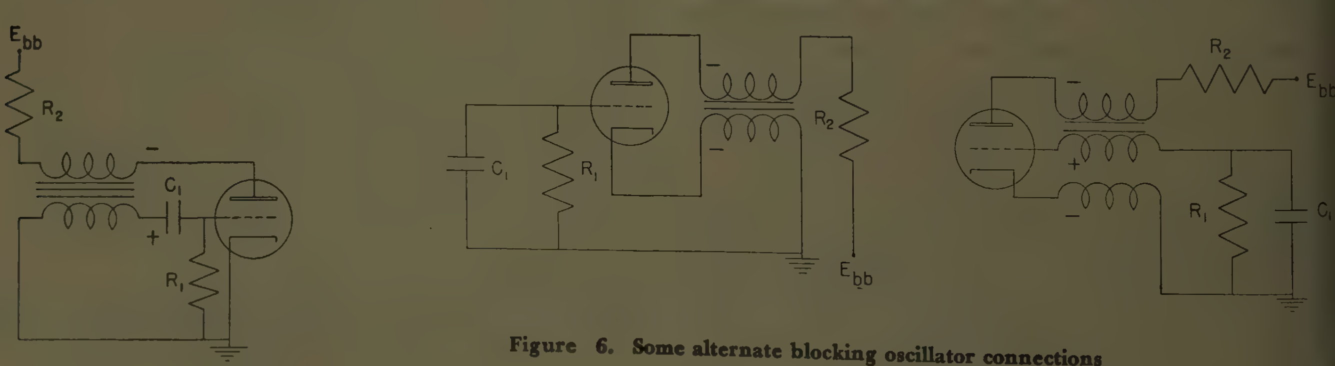
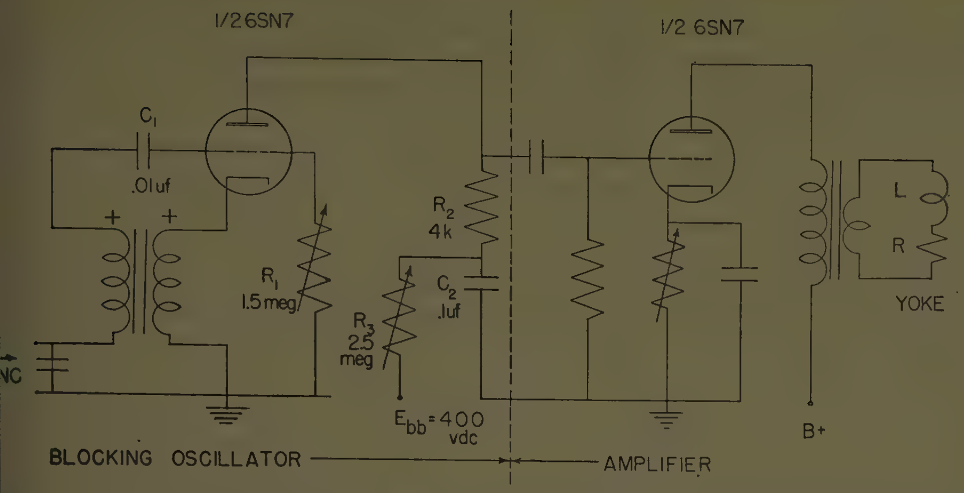


Figure 6. Some alternate blocking oscillator connections



gure 7. Typical blocking oscillator in the vertical scanning circuit of a television receiver

rrent during conduction, and is necessary to produce a vtooth of current in the yoke which has some inductance.

SYNCHRONIZED OPERATION

UP TO THIS point the blocking-tube oscillator has been discussed primarily as a free-running device, and little tinction, if any, has been necessary between the vertical d horizontal oscillators. In actual use in a television eiver, the oscillators are synchronized, of course, and ere are certain practical problems encountered which n be treated most conveniently by separating the dis-ssion of the vertical and horizontal cases.

The vertical synchronization is achieved in many tele-ion sets by operation of the oscillator at a free-running quency somewhat below the sync repetition rate, and ecting the sync pulse on the grid of the oscillator so as control the "firing" time. The practical problems countered in connection with the vertical blocking-tube cillator have to do with:

1. Loss of synchronization due to excessive drift of e-running frequency.
2. Interlace.
3. Noise immunity.

The average repetition period of the free-running oscilla- is approximately equal to $2.3R_1C_1 \log E_o/E_{co}$ where is the voltage developed across C_1 due to the charge cumulated during the pulse, and the E_{co} is the value of id cutoff at the end of the period which is a function the plate voltage. Resistor R_1 and capacitor C_1 are bject to drift with temperature. E_o is proportional to e pulse width and grid current, and is expressed by $C_1\int i_g dt$ during the pulse interval.

Drift of C_1 in value effects E_o in a direction which par-lly compensates for the change in C_1 in the equation for e repetition period; that is, an increase in C_1 results in a crease of E_o during the pulse.

In television receiver applications, the blocking oscillator quency variation over long periods results from changes in ate voltage, temperature drift, and aging of components. suitable choice of components and voltage sources ese causes of drift are minimized. Reliability of syn-chronization also is enhanced by minimizing drift.

Figure 9 demonstrates the manner in which the vertical sync pulse is integrated from the stripped composite sync signal. The time constant of the integrator must be short enough to allow the charge from the horizontal and equalizing pulses to decay to zero before the first vertical serrated pulse occurs in order that the timing of $1/2H$ between the integrated vertical sync pulses be preserved. The dotted line illustrates the effect of excessive integration in changing the timing. After field A has been painted on the receiver cathode-ray tube, the beginning of field B occurs one-half line sooner and is painted between the lines of field A resulting in equally spaced lines and interlaced, provided the timing is not destroyed somewhere in the system. Since the achievement of interlace is dependent upon uniformity of repetition of the vertical scan, and since this required uniform repetition involves a variation in starting time of half a line relative to the horizontal starting time for consecutive fields, it follows that interlace will be

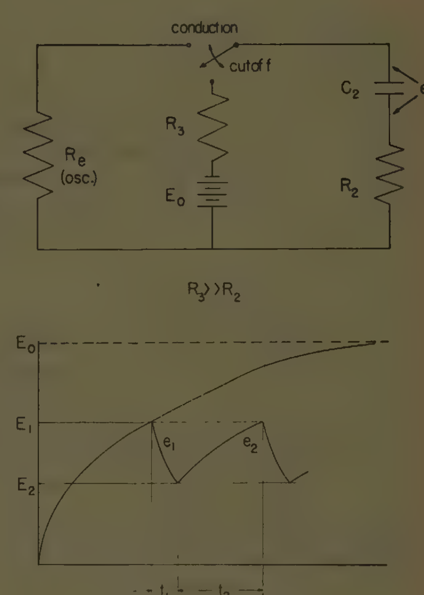


Figure 8. Analysis of the sawtooth waveform generated across C_2

$e_1 = E_1\epsilon^{-t/(R_2+R_e)C_2}$

$t_1 = 2.3(R_2+R_e) C_2 \log E_1/E_2$

$e_2 = E_0-(E_0-E_2)\epsilon^{-t/R_3C_2}$

$t_2 = 2.3(R_3C_2) \log (E_0-E_2)/(E_0-E_1)$

destroyed if the horizontal pulses in some manner gain control over the precise vertical deflection starting time.

This variation in the timing of the vertical blocking-tube oscillator required to impair interlace is so small that the presence of very small amounts of horizontal frequency component will produce the undesired timing variation.

The integrated vertical sync pulse appears across the last integrator capacitor which is in series with the blocking oscillator grid circuit. During the period before the flow of grid current, the grid winding and its shunt capacitance

smooth out the notches in the sync pulse caused by the serrations in the composite vertical sync signal. At the time grid current begins to flow, the grid-to-cathode resistance of the triode, which is in series with the transformer inductance, discharges the integrator network while the remaining serrated vertical pulses are attempting to charge it. After the last serrated pulse the integrator is rapidly discharged except for the small energy supplied by the remaining equalizing pulses. The trailing edges of the integrated vertical pulses are timed properly and they will not interfere with the natural termination of the blocking oscillator grid pulse if its length is not greater than $3H$. Since the oscillator may be fired at any point on the leading edge of the vertical pulse and if the oscillator pulse is greater than $3H$, its termination may occur in the region after the vertical pulse. Here it is conceivable that the unavoidable integration of the horizontal pulses may influence the termination of the grid pulse and impair the timing for good interlacing.

In practice, however, it has been found that the most serious source of imperfect interlacing of fields usually is the stray pickup on the grid or plate of the oscillator of voltages generated in the horizontal sweep circuit.

The gradual manner in which the grid pulse approaches zero voltage after firing renders it vulnerable to premature termination by small horizontal pulses of pickup, and impairs interlace even though the oscillator may have and the positive oscillator grid pulse should be terminated sharply. Usually all of these things cannot be done without introducing other undesirable effects so a considerable amount of cut-and-try experimentation is necessary to achieve good interlacing without sacrificing other requirements of the circuit.

OSCILLATOR NOISE IMMUNITY

Up to this point little has been said about the effect on the frequency stability of the blocking oscillator of noise detected along with the synchronization signal in the television receiver. It is the usual practice to pass the detected composite sync through amplitude limiters which clip the top and bottom of the signal, and it is this stripped sync, along with any remaining noise, that is fed into the vertical pulse integrating network. Therefore the noise present between the sync pulses and in the serrations of the vertical sync will be integrated as well as the sync pulses. It is believed that the majority of the noise encountered in the field is of such a nature that in some cases its energy content may be sufficient to integrate to magnitudes comparable to, but only in a few cases exceed, the magnitude of the integrated vertical sync pulse. In addition, the noise appearing in the vertical serrations will be integrated and ride on the resultant integrated vertical sync pulse.

It will be shown that the noise immunity of the blocking

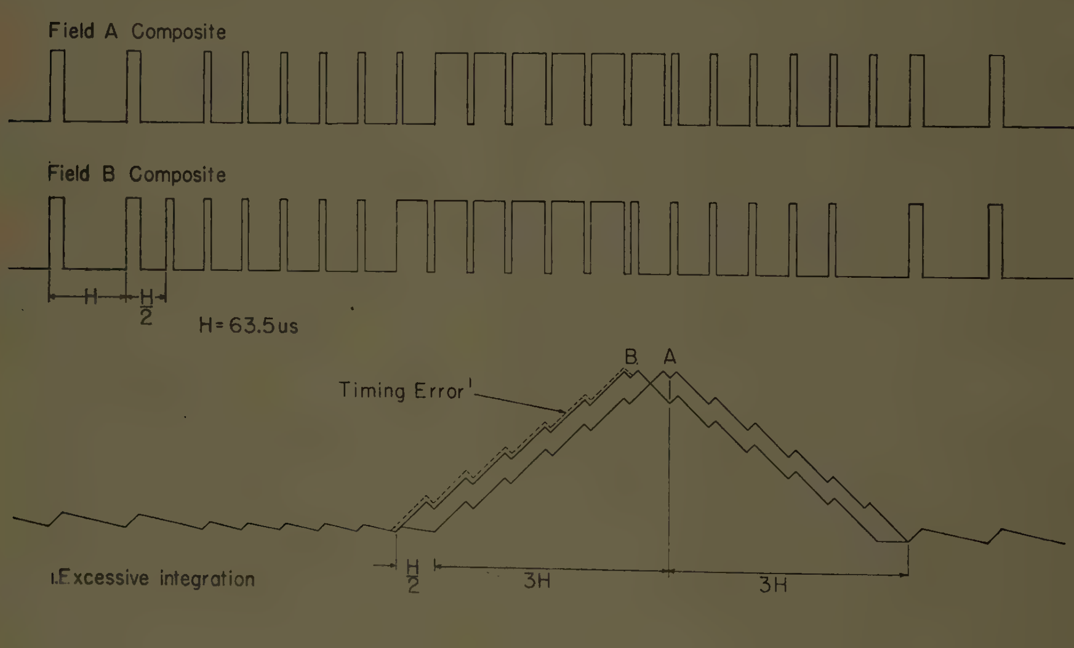


Figure 9. Clipped composite sync and resultant integration of vertical serrated pulses

been fired properly. Anything done to steepen the decay of the positive grid pulse as previously discussed will reduce the error of termination.

In summary, therefore, for best interlacing, the synchronizing pulse should be free from spurious horizontal component voltages, the integrator should give uniform pulses, the vertical oscillator circuit should contain a minimum amount of horizontal sweep voltage pickup, the blocking oscillator pulse time should be smaller than $3H$ in order that the trailing edge of the vertical sync pulse will not coincide with the termination of the grid pulse, oscillator is limited primarily by the free-running frequency stability and only slightly improved by increasing the angle between the grid voltage discharge curve and the grid base line. In Figure 10, are shown the grid voltage discharge waveforms for the simple exponential and the well known sine-wave stabilized oscillators. It will be assumed that both oscillators have identical frequency drift characteristics. ΔT is indicative of the minimum range in repetition period necessary to prevent the oscillators from drifting out of synchronization. It is seen that a larger synchronizing pulse is necessary to provide the same ΔT in the sin

illator. If the repetition periods are varied over their old" ranges, the dotted lines connecting the sync peaks ow how they are superimposed on the discharge curve. is valid to assume that the sync signal fed into the sine illator has the same sync pulse to integrated noise ratio the exponential oscillator. Then, if the oscillators are ichronized at the extreme right end of the hold range, , the shaded areas indicate the magnitude of the noise cessary to extend into the grid base line and fire the cillators. The small area at the extreme left indicates possibility of integrated noise exceeding the sync pulse ignitude but usually will not be greater than the amount the vertical pulse energy lost during the serrations. The io of the shaded area to the total area traced by the ding peaks of the sync pulses is a comparison of noise munity. The ratio is slightly higher in the sine oscillator t not enough to warrant the small gain since the sine illator for a large ΔT is very easily thrown out of sync it is synchronized close to its free-running frequency oscillation.

The optimum condition for noise immunity occurs when sync pulse is firing near its peak where the integrated ise must be greater than the sync pulse. On the other nd, noise occurring in the serrations and riding on the ding edge of the vertical pulse may cause objectionable mping or vertical roll in the received image.

It follows that if the free-running frequency stability is proved then the hold range may be minimized with a bsequent reduction in the vulnerability of the oscillator off-frequency noise firing.

In some instances, the hold range is decreased by de-easing the sync pulse amplitude and then putting the ld control on the receiver front panel. The user then anually has to compensate for drift in the oscillator quency, but, on the other hand, can set the control for optimum noise immunity.

In regard to noise immunity, the grid-plate coupled ocking oscillator in Figure 6 has the disadvantage in that coming noise during the period of cutoff is coupled into output circuit by the interwinding capacitance and is ded to the output saw voltage. This results in vertical ter of the received image during the scanning time.

On the other hand the grid-cathode coupled oscillator id circuit is isolated from the output during cutoff and ows superior performance in the presence of noise during scanning interval.

No data have been taken on the plate-cathode coupled cuit in this respect but it is believed that it is comparable the grid-cathode coupled oscillator since the grid is also lated from the output.

THE HORIZONTAL BLOCKING OSCILLATOR

To obtain synchronization of the horizontal blocking oscillator, the synchronizing pulses usually are fed to a circuit which develops a d-c control voltage which a function of the frequency of the sync. The time nstant of this circuit is made sufficiently long so that it ll not react to short bursts of off-frequency noise. This control voltage then is applied to the grid of the blocking cillator to control its frequency.

The practical problems encountered in maintaining horizontal synchronization are:

1. Loss of synchronization due to drift of free-running frequency, which may be dealt with in the same manner

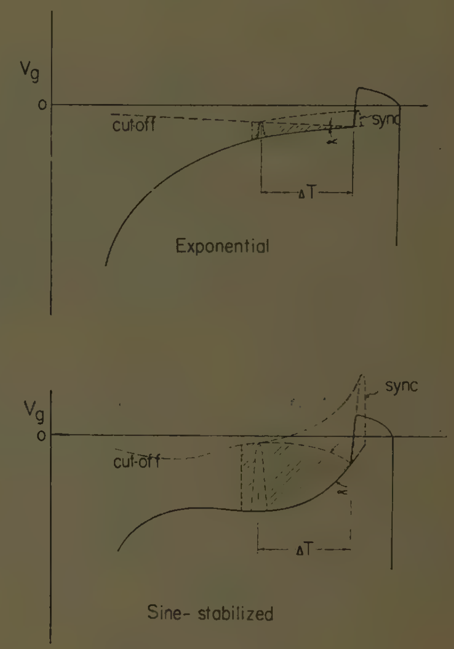


Figure 10. Comparison of noise immunity of exponential and sine-stabilized blocking oscillators

as in the vertical oscillator by suitable selection of components for minimum drift.

2. Noise immunity.
3. Weave and bends in picture due to consecutive cycle instability.

Since the horizontal blocking oscillator frequency is controlled by a d-c voltage developed by the synchronization pulses in a preceding circuit, the noise immunity is mainly a function of the ability of this circuit to discriminate against off-frequency noise.

In the simple horizontal blocking oscillator the grid voltage during cutoff approaches cutoff very gradually and in an exponential manner. This renders the oscillator vulnerable to small errors in firing time from one cycle to the next and must be compensated.

A sync pulse would ordinarily increase the rate at which the grid approaches cutoff and fire the oscillator more reliably.

In absence of a sync pulse in the horizontal blocking oscillator, the approach of the grid voltage to cutoff may be accelerated by the widely used method of sine-wave stabilization, shown in Figure 10. Here an inductance-capacitance circuit discharges in an oscillatory manner after termination of the grid pulse. The ring frequency and Q of the tank are adjusted to make the end of the first cycle steepen the usual exponential grid voltage. The ring also is applied to the plate in phase with the grid ring so as to make the cutoff voltage oscillatory and approach the grid voltage very steeply, producing a large angle, α. The grid voltage under these conditions is approaching cutoff at a high rate, somewhat comparable to the leading edge of a sync pulse, and improves the stability of the oscillator with regard to consecutive cycles errors.

Handling Logs by Electric Motocylinders

H. A. ROSE
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FOR YEARS sawmills have used various forms of specialized machinery to produce reciprocating and oscillating motions for log and timber-handling operations. Until recently this machinery was powered by steam (air) cylinder and piston, simple devices well suited to the applications, being fast, powerful, of low cost, and of rugged construction, an essential service requirement. Sawmill waste was used to generate the mill's total steam and power requirements.

During recent years the economic pattern has been changing steadily. Waste wood is going into pulp or other higher-valued products. Hogged fuel is becoming scarce. Steam, once available in unlimited quantity, has become a scarce or valuable product. Steam plants have become costly and expensive to operate, except for large mills which use dry kilns, planing mills, or by-product plants in conjunction.

The disadvantages of cylinder-type mechanisms, once of little consequence, today are of considerable economic importance.

These disadvantages are:

1. Wastefulness of steam (air) when total losses incident to its generation and utilization are included.
2. High maintenance of the plant system, including problems of cylinder lubrication.
3. High investment cost of the steam plant. This is of prime importance for small mills if purchased power can be had at attractive rates.

This article introduces the motocylinder, a powerful completely electric motor-driven thruster device for use in place of cylinder-type thrusters. The name is a contraction of its mode of operation and the name of the device for which it substitutes.

Figure 1. Three-horsepower true motocylinder. Note compact construction of unit, motor-mounted brake, limit switches and adjustable operating cams, heavily constructed non-adjustable base. Upper half of gear case removable for inspection without disassembling unit

The motocylinder is essentially a heavily constructed gearmotor with a short, powerful, crank arm mounted on the output shaft. See Figure 1. The crank is connected to the driven mechanism by a connecting rod. Rotation of the geared crank arm develops the required force and reciprocating motion. Fast-acting electric limit switches cause the motor to stop at definite stroke positions as determined by an electric motor-mounted brake. Operator's control is from a conveniently located control station with circuits arranged for any combination of start, stop, inch, hold, reverse, and automatic operation as may be required. See Figure 2.

Figure 2. Automatic motocylinder-operated roll case unloader transferring log to deck chains. Operation initiated by farthest end of log breaking light of electric eye control

For applications requiring slow speeds and/or extremes of lift or shock forces, the crank may be set apart from the unit and driven by heavy-duty chain. Such drives are called offset motocylinders.

Motocylinders are powered usually by 300 per cent high-starting torque induction motors with heavy-duty American Gear Manufacturers Association class-III service gearing to match. Totally enclosed nonventilated motors and brakes prevent entrance of sawmill dirt and water to the windings.

Energy required for operation is practically nil. Power demands are moderate. Motocylinders may be installed in practically any mill without change in capacity of an existing power system.

A considerable number of installations are in service in Pacific Coast mills. It is expected that eastern mills and other industries may find the motocylinder an economic solution to their material-handling problems.

Digest of paper 51-302, "Handling Logs by Electric Motocylinders," recommended by the AIEE Committee on General Industry Applications and approved by the AIEE Technical Program Committee for presentation at the AIEE Pacific General Meeting, Portland, Oreg., August 20–23, 1951. Scheduled for publication in AIEE *Transactions*, volume 70, 1951.

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Loudspeaker Systems in Power Plants

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Public address, or loudspeaker, systems can perform many useful functions in a generating plant which are not as readily performed by other types of communication systems. Here are presented those factors of this particular application of public address systems which must be considered in designing the system.

THE USE OF public address systems in generating plants is a special application of these devices and has not been particularly well covered in the technical literature to date. It differs from other public address applications in several important respects and it is the intent of this article to give the basic requirements leading to the design of a practical system. Trials in practical plants over the past 15 years provide a basis for selecting components most suitable. First, it is necessary to consider what other devices for communication may be at the disposal of plant operators.

Leased telephone lines. These circuits handle all normal business functions from the plant to the local central office and to long-distance phones.

Intercommunicating telephones. These take care of person-to-person conversations within the plant and may or may not be tied through a private automatic exchange or private branch exchange to external trunks.

Code calling. This is for paging key men throughout the plant and is usually a part of the intercommunicating telephone system.

Test telephone. This is a system of complete simplicity, being generally no more than a pair of conductors running throughout the plant with arrangements for plugging in handsets at any desired location.

Transmission telephones. These provide communications to substations for matters having to do with the flow of energy.

Carrier current telephones. These are provided for the long-distance conversations to other plants and substations on the main transmission system and are used almost entirely for system operating functions.

Radio. Where provided, this is used primarily for dispatching line maintenance crews and sometimes serves for directing switching at remote, unattended substations.

THE NEED FOR PUBLIC ADDRESS SYSTEMS

WITH ALL THESE facilities there is still need for some means of paging all plant personnel either individually or in groups, a means of conveying orders to groups of people simultaneously, a means of communication from any one of these individuals to the entire group, and a means of notifying all personnel in cases of emergency. This is capably disposed of by a properly designed public address system.

Early attempts to apply this equipment involved installations made by the manufacturer who, it often developed, was not fully cognizant of the problem, considering the noise levels involved, temperatures, humidity, vibration, and so forth. The equipment was not properly adapted to the service and performance was poor. Such devices as crystal microphones with their inherent fragility would not today be considered for such an application. Similarly, microphones of low output level would not be considered except possibly by using a preamplifier at each microphone to reduce the susceptibility of the microphone circuit to pickup from the many power conductors. Amplifiers attained a maximum rating of about 50 watts. Where additional power was required it was obtained only by using more 50-watt amplifiers. Thus, if 250 watts output was required the tube complement of all amplifiers totaled something in the order of 50 to 60 tubes.

Another early error was the attempt to cover entirely too much area, with the result that reverberations from the building destroyed intelligibility at any appreciable distance from the loudspeakers.

The problem, then, is to provide: a system capable of paging simultaneously throughout the entire plant; a system providing speech coverage in all operating areas; a means of reply or break-in from any operating position; and a simple means for adjusting audio power level for any background noise level from that of office areas to that of fan floors.

BASIC CONSIDERATIONS

KNOWLEDGE OF noise levels and reverberation characteristics coupled with an understanding of the manner in which a plant is operated leads to the premise that it is unnecessary and, in fact, improper to attempt to cover all plant areas except possibly for paging. The essential requirement is met by selecting and locating speakers to cover only observation and control areas where personnel normally are stationed. The speakers then may be supplemented by a means of conveying detailed information without error. High reliability must be achieved through selecting components designed to withstand extremes of

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Table I. Noise Levels and Loudspeaker Power Requirements

	Location	Noise Level (Decibels)	Loudspeaker Power (Watts) A	Loudspeaker Power (Watts) B
1.	Fan Floor	95–120	20	20
2.	Fan Floor	95–120	20	
3.	Coal conveyor	92– 97	20	
4.	Coal pulverizers	96–103	10	
5.	Scale floor	95–105	10	
6.	Heater floor	92– 97	20	
7.	Burner deck	93–101	10	10
8.	Burner deck	93–101	10	10
9.	Utiliscope (water level)	95	5	
10.	Utiliscope (burners)	95	5	
11.	Evaporator floor	93– 95	10	10
12.	Control room	70– 91	5	5
13.	Turbine room	93–107	20	20
14.	Turbine control panel	90–105	10	10
15.	Steam driven exciter	100–103	10	
16.	Boiler control panel	93–103	10	10
17.	Boiler room basement	100	20	20
18.	Boiler room basement	100	20	20
19.	Turbine room basement	90–107	20	20
20.	Feedwater pump	102–105	20	20
21.	Condenser pit	95–103	20	20
22.	Circulating pump	91–104	10	10
23.	Pump panel	98–105	10	10
24.	Condensate panel	102	10	
25.	Hotwell pumps	99	10	
26.	Machine shop	75– 85	10	10
27.	Elevator	81– 96	*	*
28.	Superintendent's office	67– 75	0.5	0.5
29.	Watch engineer's office	74– 81	0.5	0.5
30.	Electrician's office	74– 81	0.5	0.5
31.	Storeroom	83	5	5
32.	Amplifier room	75– 85	0.5	0.5
33.	Electric gallery	84– 91	5	
34.	Chemistry laboratory	78	1	
35.	Results department	82	1	
36.	Lobby	82	5	
37.	Hallway	77– 91	1	
38.	Screen house	93	10	10
39.	Transformer yard	91– 96	10	
40.	Outside, near plant	75– 95	10	
41.	Outdoor substation	71– 82	10	
42.	Gate house	73	1	
	Total power		406	242
	Number of loudspeakers		41	22
	Average power		9.9	11.0

Column A—Complete coverage. Column B—Minimum requirements.
* Handset but no loudspeaker provided.

temperature, humidity, dirt, and mechanical abuse. Consideration must be given to the great lengths of microphone and speaker cable, and their selection and installation as a matter of minimizing susceptibility to magnetic and electric fields. The method of operation at each control point must be as simple as possible. The circuits employed must be held to basic simplicity to avoid becoming future sources of trouble and so maintenance work may be done without the necessity of calling in people with special skills or equipment.

If it is impractical to provide acoustic treatment of any areas other than offices or control room, it is necessary to adapt speakers to the plant as it stands. If, for instance, it were attempted to cover an entire turbine room floor from a single speaker, it would be found impossible regardless of the sound power employed because the large ceiling, wall, and floor areas cause reverberation sufficient to completely destroy intelligibility. If the entire area must be covered, many small units must be used. Actually a practical solution results from the use of a single speaker at the turbine control panel or at the control end of each unit to concentrate all sound energy in those areas where operators are normally on duty. Similar logic applies to the application on the fan floor or other places where large wall areas may reasonably be expected to give trouble.

Many observations were made in both old and new plants using a Western Electric Company Sound Level Meter type *700-A*. These readings are tabulated in Table I, the values being in decibels above the threshold of hearing, which is taken as zero level, or 10^{-16} watt per square centimeter. Noise levels indicated are generally between 80 and 120 decibels with a few exceptions as in soundproofed offices and control rooms.

Table I gives average noise levels based on observations in practical plants. The final column indicating loudspeaker watts for each location has been determined by experience. This is not directly related to the noise level since there is an additional factor of the area to be covered. Note that the average for an entire plant is in the order of 10 watts per speaker and the total requirement for a single unit plant is in the order of 250 watts.

In the production plant itself and in outdoor areas, all speakers should be of the horn type using either straight trumpets or re-entrant horns. For our purposes, the smallest horns manufactured are entirely suitable. Specifically, a horn providing a $2^1/_2$–$3^1/_2$-foot air column with a bell diameter of 12 inches will pass everything from 150 to 5,000 cycles essentially without distortion. As the intent is to cover only selected areas, these horns should be chosen with not more than 40-degree spread at 1,000 cycles. Drivers of the permanent magnet type attained a high degree of development for military applications and are available today in forms which are practically impervious to temperature, humidity, vibration, or dirt as would be encountered in a generating plant. These are available in various sizes from 5 to 25 watts. For simplicity and interchangeability, it is recommended that just one type, say the 25-watt size, be provided.

In the control room a ceiling type 360-degree unit may be employed although a small 5-inch cone speaker mounted in one control panel is adequate. For office areas the sloping panel type speaker mounted at the junction of

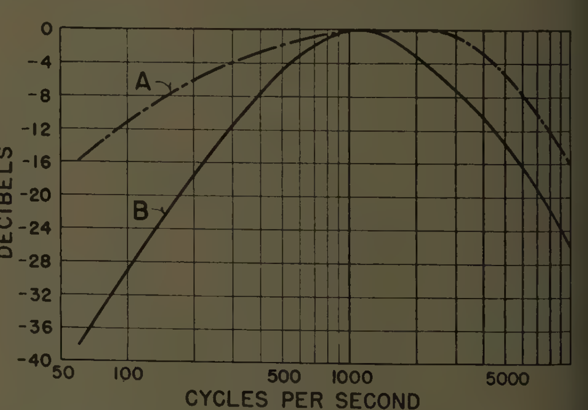
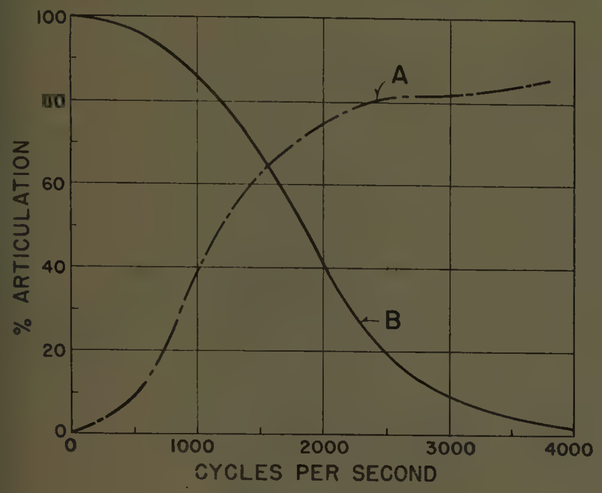


Figure 1. Suitable response characteristics for the amplifier

wall and ceiling is satisfactory. In large offices where only certain of the employees are directly concerned with operation of the physical plant, it is convenient to use one or more small desk speakers in plastic housings.

Having in mind the over-all response characteristic indicated in Figure 1, it is apparent that any modern

icrophone will provide adequate fidelity. Crystal micro-ones should be avoided because of their fragility and the ct that they are subject to damage from temperature and imidity. Dynamic microphones would be quite suitable it in general involve more expense than necessary. The al practical solution appears to be through the use of a



gure 2. **Effect on syllable articulation of removing portions of e speech frequency range.[4] All frequencies below those dicated on curve A are transmitted, while all frequencies above those indicated on curve B are transmitted**

nventional carbon microphone, preferably in the form a telephone handset. These have been highly de-loped, specifically for transmission of speech intelligi-lity, and are most desirable in this application because their extreme ruggedness, low cost, and general avail-bility. There is one further advantage in that they ovide a high-level low-impedance source which reduces e susceptibility to pickup in the long microphone line hich may run to the order of 1,000 feet. Also, no pre-nplifiers are required either at the individual microphones ahead of the main amplifying device. Since the system volves only a total amplification in the order of 60 ecibels, the matter of microphone hiss is not a problem.

In levels of extremely high noise, intelligibility of sound ming from loudspeakers is limited to simple words, imes, or phrases. For anything more detailed, it is ecessary to listen to a telephone receiver and, where the om noises are particularly bad, to have the additional otection of a soundproof booth. The conventional onophone suggested above serves very well for this lditional function.

Considering the necessity of controlling plate voltage d the need to cut off local loudspeakers, the simplest eans is through the use of microphone current for control. hus the microphone supply must not only be filtered lequately but should have high enough voltage to operate o relays in series with the microphone. Assuming that 0-ohm telephone relays and a conventional carbon icrophone are used, this requires a 48-volt supply which available in any of a number of forms; for instance, as power supply for use in small telephone exchanges or as a part of a carrier current telephone set or a radio trans-mitter. This arrangement also has the advantage that no additional conductors are required for control.

AMPLIFIER CHARACTERISTICS

THE FIRST thought is normally for a means of designing or selecting high-fidelity equipment. However, in this application there is no intent to use the device for entertainment or reproduction of music. Not only is capability along these lines unnecessary but actually detrimental. In a power plant the background noise, although high, does tend to concentrate at either end of the audio spectrum. Thus we have many rumble noises as from crushers, fans, and so forth, and hum from motors and transformers. At the upper end of the spectrum we have the characteristic screaming of turbine blades and feedwater pumps.

Figure 2 indicates the effect on syllable articulation of removing portions of the speech frequency range.[4] Note that no substantial improvement results from extending this range either below 400 cycles or above 3,000 cycles and adequate intelligibility will be attained by concentrat-ing all audio energy within this range.

Figure 3 indicates the relation between articulation and energy distribution of speech. About one-half of the total energy is confined to the frequencies below 500 cycles but these frequencies contribute only 5 per cent to the intelligi-bility. By eliminating most of these and concentrating everything in the 400- to 3,000-cycle range, a given size of amplifier and number of speakers will provide far better performance.

What would be called a high-quality amplifier for voice might have an over-all fidelity characteristic as indicated by curve *A* of Figure 1, which is flat from 1,000 cycles to 2,500 cycles and down 6 decibels at 200 cycles and 5,000 cycles. Even this is far more linear than required and an amplifier with characteristics as indicated in curve *B* would be satisfactory. This peaks at about 1,000 cycles and is down 6 decibels at 500 cycles and 2,500 cycles. In a power plant there is much opportunity for magnetic pickup into

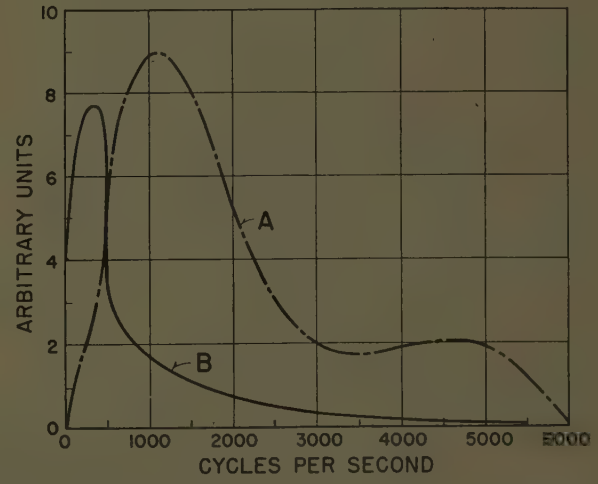


Figure 3. Relation between articulation and energy distribution of speech. Curve A shows relative importance for intelligibility, while curve B shows energy distribution

the microphone circuits of 60-, 120-, and 180-cycle frequencies and the amplifier response to these low frequencies must be held down. Thus, continuing curve *B*, the roll-off below 500 cycles and above 2,500 cycles could be designed for about 12 decibels per octave. This, and in fact the entire shape of the over-all characteristic, may be obtained by very simple resistance-capacitance networks.

DESIGN OF AMPLIFIERS

A SIMPLE AND practical arrangement for this type of work would be through the use of a single triode, say type *6J5*, or a pair in push-pull for the input stage followed by a pair of triodes, say type *6A3*, in push-pull as a driver stage, these all being operated in class A, and followed by a final stage consisting of a pair of *805*'s in push-pull operating as either class AB or class B. A pair of *866A* tubes would suffice as plate supply for the final stage using a bleeder to feed input and driver stages. If desired, the input and driver stages could be supplied from a low-voltage rectifier which might include the microphone supply mentioned. Thus the entire amplifier, including rectifiers, totals only 7 or 8 tubes.

Degenerative feedback for final stages using beam power tubes is conventional and can be introduced with little difficulty to reduce distortion, noise, and instability caused by voltage fluctuation and, at the same time, improve output regulation of the amplifier.

Assuming class AB or B is used in the final stage, a power supply of good regulation is required. This is readily accomplished through the use of mercury rectifier tubes with choke input filter. Considering the comparatively low gain of the amplifier, there will be no trouble from rectifier tube noise if a conventional hash filter is employed.

The transformers themselves must be designed with

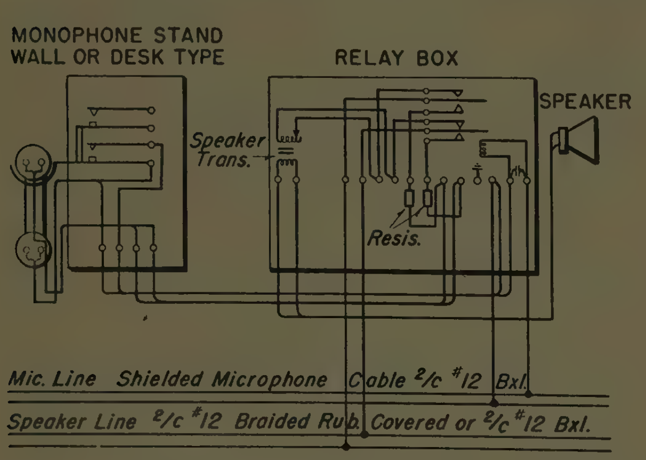


Figure 4. Circuit for relay control box, handset, and hookswitch

consideration for such factors as saturation of core material, symmetry of windings, avoidance of resonance, low loss, and adequate shielding against hum pickup from chokes and other transformers. Many well-designed transformers are available.

The basis for choice of tetrodes or triodes may be argued. However, either one may be employed to produce an amplifier of adequate fidelity. For audio work of this nature the triode was used since there is some reason to believe it is more capable of retaining its original characteristics throughout its life and is somewhat less subject to failure from "hot shorts." Considering the comparatively low total gain, separate cathodes are not required except possibly in the first stage. Conventional receiving type

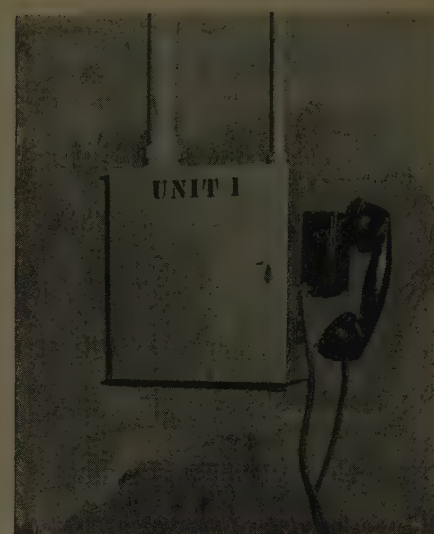


Figure 5. Typical monophone station mounted on relay control box

tubes are available in many types for the input and driver stages and many transmitter tubes, such as types *211*, *805*, *811*, *838*, and *845*, are available for use in the final stage.

Since amplifying systems of this type are in use for only a small percentage of the total time, it is advisable to disconnect the plate supply during the idle periods. This is a simple matter and will result in material extension of tube life and, at the same time, will reduce temperatures of all other components of the amplifiers, thus similarly extending their lives. A thermal relay should be incorporated in the plate supply as a matter of protecting the rectifier tubes whenever the supply voltage may be interrupted and restored.

In a power plant there are many possible locations. If a separate room is provided for the telephone switchboard, carrier current equipment or other electronic devices, it would be ideal. Otherwise, there may be space in the control room or one of the offices. If none of these is practical, an amplifier designed along the lines indicated here can be located almost anywhere as long as the ambient temperature does not exceed about 90 degrees Fahrenheit and the equipment will not be subjected to excessive vibration or direct spatter of liquids.

The standard desk set cords and handset cords are not available as shielded conductors or even with the microphone lead shielded. It is therefore important to reduce the level of the speaker line to handset level before bringing it into proximity to the microphone lead. Thus the speaker line in the control box goes immediately to the relay and then through resistances to the flexible cord. The value of these resistors may be changed to produce any desired receiver volume depending on the background noise level. Using resistors in pairs to maintain balance

assuming a 122.5-volt speaker line (250-watt amplifier, hm line) and handset receivers of 60 ohms each, the wing receiver power levels will be produced:

as	Total Watts	Watts in Receiver
00	3.36	0.0452
00	2.25	0.0203
00	1.58	0.0100
00	1.10	0.00483
00	0.749	0.00224
00	0.340	0.000463
00	0.227	0.000206
00	0.160	0.000102
00	0.110	0.0000485
00	0.075	0.0000225

hese matching transformers serve the purpose of matching the impedance of all speakers in parallel to whatever edance it is desired to operate the speaker line. Thus individual speakers are set for impedances considerably ve that of the line itself. For instance, if we operated ne at 60 ohms, the following table would indicate edance to be used to obtain any desired speaker power.

ker Power (watts)	Transformer Impedance (ohms)
25	600
20	750
15	1,000
10	1,500
5	3,000
2.5	6,000
1	15,000
0.5	30,000

simplicity it is suggested that all horn speakers be ipped with 25-watt adjustable transformers to cover impedance range from 600 to 3,000 ohms. Transformfor all other speakers could be 5 watts rating with input edances from 3,000 to 30,000 ohms.

or example, in the installation suggested in Table I er condition B, there are seven 20-watt speakers, nine watt speakers, two 5-watt speakers, and four 1/2-watt akers. Using transformer input impedances as inated, the total speaker power is calculated as follows:

7 Units, each 750 ohms in parallel = 107 ohms
9 Units, each 1,500 ohms in parallel = 167 ohms
2 Units, each 3,000 ohms in parallel = 1,500 ohms
4 Units, each 30,000 ohms in parallel = 7,500 ohms

$$\text{l impedance} = \frac{1}{1/107+1/167+1/1{,}500+1/7{,}500} = 62$$

$$\text{l power} = \frac{(122.5)^2}{62} = 242 \text{ watts}$$

or both microphone and speaker lines there are many ctical choices. These should be restricted to the types erally found in plant stocks for which fittings are nediately available and with which the plant personnel thoroughly familiar. For instance, the speaker line ld consist of either *BX* or number 12 weatherproof wire onduits. For the microphone line type *BXL* would be ellent. The characteristic impedance of these lines ot a factor since for the highest frequency handled, say 0 cycles, we have a wavelength of approximately 62 miles compared with a length of the longest run of cable in the order of 1,000 feet.

It is advisable, wherever possible, to keep microphone and speaker leads in separate conduits. The microphone circuit may be carried in the same conduits with other signaling circuits if desired.

In addition to the loudspeaker and the desk set the control room should have jacks in the panels so that an operator may use a portable monophone while working at the panels, reading instruments, and making adjustments. A conventional double telephone jack located every alternate panel will be adequate. The operator uses a standard monophone with 4-wire cord and double plug. Plugging in the portable monophone accomplishes the same thing as picking up the desk set monophone in that the local speaker is cut off.

To eliminate acoustic feedback it is necessary to provide a relay at each control point to cut off the local speaker when its associated monophone is off the hook. For convenience, this is mounted in a 12 by 12 by 4-inch steel box (see Figure 4) with a 10-microfarad capacitor by-passing the relay coil, a pair of fixed resistors to apply a low level signal to the handset receiver, and an adjustable speaker transformer. The steel box is well adapted to welding or bolting to steel structures throughout the plant and is of ample size to accommodate *BX*, *BXL*, or conduit. For office areas, the same components in smaller size may all be built into a standard telephone ringer box.

OVER-ALL PERFORMANCE

As it normally functions, the system is put into operation by lifting any monophone which, in turn, applies plate voltage and the call is received by all speakers. Assuming that a certain person is called, when he picks

Figure 6. Amplifier cabinet from the rear with covers removed. Inside are the master switch, 48-volt rectifier, monitor, control panel, 250-watt amplifier, and terminal panels

up the monophone at some other point, a high quality telephone channel is established with receivers at each end adjusted in amplitude depending upon local noise levels. It would then be a simple matter to cut off all loudspeakers. However, experience indicates that it is better to leave

Figure 7. Front view of the unit in Figure 6

Figure 8. Machine shop showing loudspeaker, control box, and soundproof booth for the handset

Figure 9. Control room operator using a portable monophone. A loudspeaker appears in the upper right corner of the panel

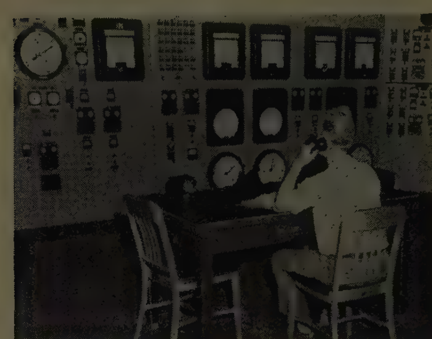


Figure 10. Contro room operator usin a desk set

Figure 11. Offic showing des speaker and mono phone

them in operation. Thus, all personnel are fully informed of any contemplated changes being discussed and may prepare to make such adjustments as necessary on the equipment under their control.

In general, the sound power being concentrated in that part of the frequency range conveying maximum intelligibility, the over-all performance is very good. However, it must be recognized that in the extremely high noise level areas, the best that can be expected from loudspeakers is to make simple words or phrases understandable. "It is common experience that when any sound is impressed upon the ear, it reduces the ability of the ear to sense other sounds."[4] Each tone tends to mask those near and above it in frequency. As would be expected, masking by complex sounds is the composite masking of each individual tone. In these areas the public address system serves for paging only, after which the transmission of intelligence i accomplished by the local monophone with the protectio of a soundproof booth.

By adhering rigidly to practical considerations as de tailed, a device may be produced using commerciall available components in circuits of basic simplicity, attair ing high performance characteristics at low cost to provid a service not possible by other communication device either separately or in combination.

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A Tribute to Dugald C. Jackson

VANNEVAR BUSH
HONORARY MEMBER AIEE

COME BEFORE YOU as one whose professional career was profoundly influenced by Dugald C. Jackson, and I venture to represent all those whose lives have thus n influenced, many of whom are here with me. It is that we should meet and remember as we do, not only ause of our respect and affection for our old chief, but because many of the things for which he stood strongly still of great moment in the professional world and thy of continued emphasis.

CAREER IN INDUSTRY

UGALD C. JACKSON graduated as a civil engineer from Pennsylvania State College in 1885, at the age of and when, two years later, he finished his graduate k at Cornell he entered an extraordinary world. The ession of electrical engineering was just beginning. re were not many engineering pioneers in those days, who entered vigorously into the new field and recog- d its potentialities, but Jackson was decidedly one of n, and he was a very significant figure indeed, even n he was young. The old profession of engineering been a rule-of-thumb affair. True, there were those had built bridges based on sound analysis, but the eral run of engineer leaned upon his experience and very little indeed to do with mathematical treatment, less with the current advances in science that were urring all about him. It was quite possible thus to ance in the older fields, for the day of their close inter- age with scientific progress had not arrived. The new ession of electrical engineering, however, was in a ly different category. One could by rule of thumb gn a mechanical machine that would work, but in r to make an electric machine that would perform in ordance with specifications, it was necessary to deal more subtle things, and to deal with them quantita- ly and precisely. In those days began a growing rrelationship between engineers on the one hand, lying science for the benefit of mankind in an economic nner, and fundamental scientists on the other, delving the laws of nature with the sole object of advancing n's knowledge of himself and his environment.

here could have been no stronger advocate of the new of professional engineering career than Dugald C. kson. The combination of talents and attributes ch he possessed fitted the new opportunities and re- nsibilities of engineers precisely, and he had the vigor determination to make himself felt. This had its y influence in industry when he helped to organize the tern Engineering Company in Nebraska and later when he joined the staff of the Sprague Electric Railway Company. His most important influence was when he became Chief Engineer of the Central District of the Edison General Electric Company, thus participating in and molding the beginnings of a vast industrial enterprise.

CAREER IN EDUCATION

BUT ITS EFFECT became most enduring when he turned to education, first for 16 years as Head of the Department of Electrical Engineering at the University of Wisconsin and then as Professor and Head of the Electrical Engineering Department at Massachusetts Institute of Technology (MIT). In these posts he molded electrical education into the form which it has taken ever since. His well-known textbooks on electricity, magnetism, and a-c machines were an important part of this influence. But his insistence on rigor in thinking, his intolerance, often forcibly expressed, of anything approaching muddy processes of reasoning, and his continued insistence that direct professional study must be accompanied by a conscious effort to advance the art, rendered electrical engineering education, in fact by its influence rendered all engineering education, a far sounder structure than it would have been otherwise. He was always a most ardent defender of his own staff before the authorities of MIT and before the world generally, but working with the staff itself he insisted in no uncertain terms that they be worthy of that support, and his insistence centered about the principle that the professional career in engineering is worthy of any man's best steel. Thus he had no patience with the dilettante, nor with the casual practitioner, and his rigorous insistence upon hard and sound work stiffened the backbone of many a neophyte. To serve under him was a stimulating experience, never one to be taken casually, nor always one that was entirely comfortable. But it was all tempered by one thing for which we all remember him most keenly.

In all his relations with his staff and with students he was the most fair man under whom an individual could possibly serve. No matter how humble the student, no matter what difficulties he might have brought upon himself, if there was the slightest indication that he had been treated unfairly, if there was the most elusive indication that he had been the victim of ambiguity in tests or otherwise, D. C. Jackson was his champion and in action until the matter was straightened out and utter justice restored.

There was something here of great import, for he had pride in his own professional accomplishment, pride in the professional accomplishments of his staff, a profound conviction that the professional life was a dignified and worthy one, and that the engineer was capable of standing on his own feet, offering no apology to the world for the existence

ext of the tribute given at the memorial service for the late Professor Jackson on er 21, 1951, in Cambridge, Mass.

evar Bush is President, Carnegie Institution of Washington, Washington, D. C.

of his profession. Moreover, his concept of a capable engineer was that of a man among men, meriting their respect, but capable of working effectively with all sorts of individuals of diverse backgrounds and attitudes on a basis of mutual regard whenever that was possible or attainable. This comes very close indeed to the concept of the dignity of men for which we struggle in this complex world, and close indeed to that idea of individual freedom and individual initiative and accomplishment which we regard as the central feature of all that we hold worth while in human organization.

His interest in the individual became exemplified in many ways. In the Department of Electrical Engineering at MIT he introduced an honors system for releasing exceptionally able students from rigorous schedules and the detailed following of texts in order to develop them individually along their own lines. He founded a system of co-operative education with industry, based not merely upon the opportunity to earn a bit of income while studying, although that was a feature, but upon the much more far-reaching belief that it is essential that there be close liaison between a teaching department in engineering and the industry which surrounds it, not only on the part of the faculty but also on the part of students of high caliber, that they may appreciate early the nature of the world which they are entering and prepare accordingly. He insisted upon an alliance between undergraduate teaching and research, with creative teachers struggling to advance their subjects, and students participating in independent investigations of their own. In all this his emphasis throughout was upon rigor, sound, logical thinking, advanced techniques, and professional judgment enhanced by close and fruitful contact with current practice.

CAREER AS CONSULTING ENGINEER

The consulting engineer occupies an extraordinary position in our society, and in the early days of an art his opportunities and his responsibilities are emphasized. In his contacts with industry he is expected to perform functions which industry cannot perform for itself, and these often include aspects which can be adequately handled only by the keenest of engineers, built into a smoothly operating organization capable of tackling any problem with which industry in all its complexity may be confronted, from the appropriate and revealing management of costs and accounts on the one hand to the technical effectiveness of projected intricate systems on the other.

It was inevitable that Dugald C. Jackson should become a consulting engineer, and he did so early and continued this relationship until he retired from active consulting practice in 1930. In 1919 he organized the firm of Jackson and Moreland, which is still one of the most important elements in the entire field of professional consulting engineering practice. To this work he brought the same habits of thought, the same insistence upon superb accomplishment that permeated his entire career as an educator. As a result he was respected from coast to coast, not only for the soundness of his opinions and the reliability of his judgment, but also because he had surrounded himself with a team of keen minds capable of working smoothly together toward difficult objectives. This group took a leading part in many engineering projects such as the Conowingo hydroelectric installation, the electrification of the Cascade Division of the Great Northern Railroad and of the Suburban Division of the Delaware, Lackawanna and Western Railroad, appraisal of many public utility properties, and consulting advice to the great public utility companies of the country on many other phases of their operations.

It was inevitable that when the First World War came he should take an active part therein. He was a Lieutenant Colonel of Engineers in France, and Chief Engineer of the Technical Board. He installed plants of great size for the support of operations, and after the Armistice he served on the War Damages Board. I will not attempt to recite all the many medals and honors that were presented to Dugald C. Jackson throughout his career, but for these particular services he was made a Chevalier of the Legion of Honor.

He was President of the American Institute of Electrical Engineers, and President of the American Academy of Arts and Sciences. Forming as he did a significant bridge between science and engineering, it was highly fitting that he should thus serve in these two great organizations. His services to the American Institute of Electrical Engineers were by no means honorary or casual. His vital personality, his dynamic defense of all he felt worthy, galvanized that organization as it invigorated every organization into which he entered.

Very few men have the opportunity to witness the changes in mode of life that were encompassed by the life and career of Dugald C. Jackson. As a boy he lived in a world where modern techniques affected very little the daily life of the individual, and as a man he saw the impact of all that now surrounds us in modern communication, transportation, and mass manufacture. Moreover, he had the joy of participating in many of these changes in their early and formative periods, and he left his imprint in many places. We who served under him are different men because he existed. We have a broader outlook upon our missions in the world, keener enjoyment in creating, and more intense insistence upon soundness of approach, because he guided us, firmly but nevertheless with a fatherly affection for those who came under his tutelage. We join today in revering his memory, for we all carry a part of this character as an element in our own.

Just one more word: We customarily in this world recognize great attainments by the giants among us, and we pay them honor. Many such honors were paid to Dugald C. Jackson by many societies and men. But we seldom recognize sufficiently that often the results which we applaud were obtained not by an individual but by a team. Dugald C. Jackson could never have accomplished all that he did if there had not always been by his side a loyal and courageous wife who sustained and supported him. She has our affection too, for it is due to her also that our lives were molded, and it was because of her that the accomplishments were achieved which rendered our profession a more worthy one. She is still with us and we hope will be with us for many years to remind us of our debts and to refresh our happy memories.

Lightning Hazards in Japan

MICHIO TANAKA

Exhaustive studies of the occurrence of thunderstorms and the effects of lightning on power lines have been carried on by the Japanese Society for the Advancement of Science. This article is a brief report to illustrate the present status of these studies.

THE PREVENTION of lightning hazards on power systems has always been an important problem in Japan, as in the United States. A Lightning Hazards Prevention Subcommittee of the Japanese Society for the Advancement of Science was organized in October 1939 to study this problem. Nearly a hundred meteorological scientists and electrical engineers took part in the work. An exhaustive field survey of thunderstorms and lightning was carried on in the Kanto District in the vicinity of Tokyo each summer until the end of World War II, when the organization was dissolved. A book entitled "Study of Lightning" was published in 1950 and gave a full record of the work of the Subcommittee and its results.[1]

Because the need for the study of lightning and the prevention of its hazards still existed, two new organizations were formed after the war. These were called Power Systems Lightning Hazards Prevention Committee and Co-operative Group Studying Relations Between Power Engineering and Meteorological Phenomena. Both of these organizations are still active.

The present article is mainly an abstract from the annual report for 1950 of the Kansai District Subcommittee of the Power Systems Lightning Hazards Prevention Committee, but it will serve to illustrate the present status of the study of lightning hazards in Japan.

ISOKERAUNIC LEVELS

IN 1948 THE Central Meteorological Observatory, Tokyo, issued maps (Figures 1 and 2) showing the frequency of thunderstorms and the number of days with cumulo-nimbus clouds (isokeraunic levels).[2]

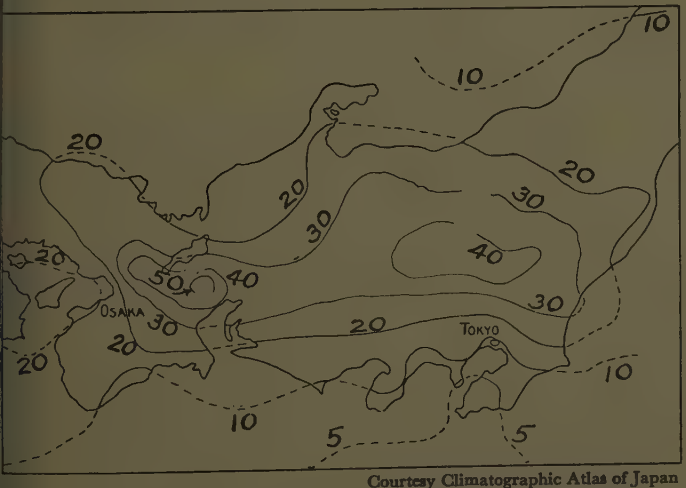
These maps showed for the central part of the main island of Honshu a range in isokeraunic level from 5 to 50, being lower in the coastal regions and higher in the interior mountainous regions. In the vicinity of Tokyo the average level was about 10, while in the vicinity of Osaka the average was 15 to 20.

In any assigned locality there were three different representations for the frequency of thunderstorms:

1. Number of thunderstorm days per year.
2. Number of thunderstorms which started in the assigned unit area.
3. Number of thunderstorms which originated in the area (item 2) plus the number which originated elsewhere but travelled through the assigned unit area.

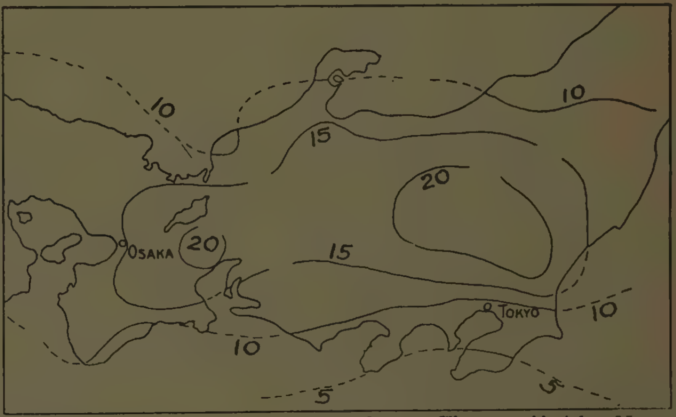
The Kinki District embraces 81 unit areas (9 in east-west and 9 in north-south directions) in the central part of Honshu in the vicinity of Osaka, Kobe, Kyoto, and Toyooka. Each unit area is 23 kilometers east to west and 28 kilometers north to south.

The values of item 2 for the years 1948, 1949, and 1950 for the Kinki District were determined by the Osaka Meteorological Observatory for each of the 81 unit areas. The number for the various unit areas varied widely from



Courtesy Climatographic Atlas of Japan

Figure 1. Map of central Japan showing frequency of thunderstorms per year



Courtesy Climatographic Atlas of Japan

Figure 2. Map showing the number of days per year with cumulo-nimbus clouds

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Acknowledgement is gratefully made to Dr. W. W. Lewis of Union College, Schenectady, N. Y., for rewriting the article to conform to American style and language.

0 to 37 in 1948, from 0 to 7 in 1949, and from 0 to 15 in 1950. The totals for the entire district for the value of item 2 for three years were: 1948, 448; 1949, 112; 1950, 190.

The values of item 1 for the Kinki District in the years 1948, 1949, and 1950 are not available but the author once investigated the values for a period previous to 1944 and found that they varied from 0 to 60 by localities, with a mean value of about 10. This would place the values for item 1 and item 2 roughly on the same level.

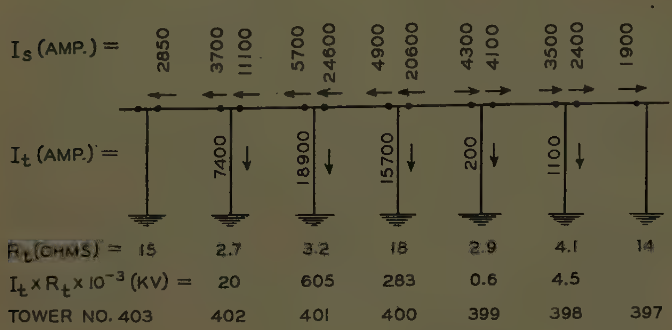


Figure 3. Typical record showing lightning surge currents recorded by magnetic links attached to aerial ground wire of Tokai trunk line, operated at 154 kv

As for item 3, the author compared the values obtained from the totals for another district, the Kanto District, for the year 1950, and found that item 3 was approximately 4.5 times item 2; that is, for every thunderstorm originating in the assigned area 3.5 thunderstorms come into the area from outside. The isokeraunic level of the Kinki District resembles that of the southwestern regions of the United States.

SEVERE STORMS IN 1950

July 24, 1950, was the worst thunderstorm day of the season. The Osaka Meteorological Observatory reported that 10 thunderstorms started in the Kinki District that afternoon between 4:30 and 8:30. These storms caused the following damage and disturbances to 77-kv and 154-kv systems: 28 cases of trouble; 208 suspension insulators broken; 69 suspension insulators discolored; and 12 lines affected.

The damage to subtransmission and distribution systems, as classified by localities, was: Osaka Prefecture, 57; Shiga Prefecture, 1; Kyoto Prefecture, 22; and Hyogo Prefecture, 11.

Classified by equipment, the disturbances were: generating stations and substations, 4; subtransmission lines, 8; and distribution lines, 79.

The Osaka Meteorological Observatory reported that 21 thunderstorms took place on July 13, but only 5 cases of trouble to power systems resulted.

Magnetic links, 198 in all, were distributed along the 77-kv and 154-kv transmission lines to measure lightning current flowing through ground wires. A typical record, obtained from these links on the 154-kv Tokai trunk line, on July 19, 1950, is shown in Figure 3.

High-speed Braun-tube oscillographs, klydonographs, and magnetic links were installed to obtain records of lightning surges on subtransmission and distribution lines at Matsugasaka Substation, Kyoto City, and in the vicinity of Urata Substation, Osaka Prefecture. In 1950 only a few minor records were obtained, which will not be discussed at this time.

Damage to underground cable by lightning is sometimes experienced, although such occasions are rare. An underground telephone cable connects the foot of Mount Ibuki in Shiga Prefecture with the summit. A few years ago this cable was severely damaged by lightning.

Magnetic links were installed in handholes along this cable. In the summer of 1950 the following values of current were indicated by these links: in number 1 handhole, 4,300 amperes; in number 2 handhole, 4,100 amperes; and in number 3 handhole, 4,300 amperes.

DAMAGE TO 77-KV AND 154-KV LINES

The following data have been presented by the Nippon Hassoden K.K., which company owns and operates the 77-kv and 154-kv lines: Lightning trouble on the 766 kilometers of 154-kv line, June 1 to September 30, 1950, 22 cases, or 2.9 cases per 100 kilometers. Of these 22 cases, 11 occurred on the Itami line, which is 44.9

Table I. Service Interruptions Due to Lightning on 154- and 77-Kv Systems

Year	1948	1949	1950
Number of service interruptions	113	17	72
Interrupted energy, kilowatt hours	1,168,370	201,103	702,743
Interrupted energy, kilowatt hours per interruption	10,340	11,830	9,760

Table II. Cases of Damage Due to Lightning on Subtransmission and Distribution Systems

Items	Year 1947	1948	1949	1950
Number of thunderstorms during this summer		403	112	189
Damages in generating and substations	22	60	38	26
Number of generating and substations	424	495	488	413
Damage rate per 10 stations	0.52	1.2	0.78	0.63
Damages to subtransmission lines	15	41	24	41
Total length of route of lines, kilometers	2,877	2,912	2,760	2,974
Damage rate per 100 kilometers	0.52	1.4	0.87	1.4
Damages to distribution lines including distribution transformers	356	969	579	1,360
Total length of route of lines, kilometers	32,454	32,802	32,954	33,666
Damage rate per 100 kilometers	1.1	3.0	1.8	4.0
Damages to distribution transformers only	230	729	370	858
Number of transformers in operation	158,914	169,578	193,036	202,920
Damage rate per 1,000 transformers	1.5	4.3	1.9	4.2

Table III. Cases of Damage Due to Lightning on Distribution Systems Counted Monthly

(*January 1 to August 31, 1950*)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1947	0	0	0	2	2	15	65	107	145	20	0	0
1948	0	0	7	9	14	13	194	419	258	51	2	2
1949	6	2	1	123	29	8	41	105	154	109	1	0
1950	41	21	1	23	29	61	485	706				
Total	47	23	9	157	74	97	785	1,337	557	180	3	2
Percentage	1.4	0.7	0.3	4.8	2.2	3.0	24.0	40.9	17.0	5.5	0.1	0.1

ble IV. Cases of Damage Due to Lightning on Distribution Systems Counted in Each Local Area

Area	Osaka	Kyoto	Hyogo	Himeji	Nara	Waka-yama	Shiga
al length of distribution ne routes, kilometers	6,605	5,356	5,152	5,862	3,761	4,210	2,718
nages due to lightning	360	270	224	85	216	117	95
nage rate per 100 kilo-meters	5.5	5.0	4.4	1.4	5.8	2.8	3.5

ble V. Cases of Damage to Distribution Transformers Due to Lightning Classified as to the Damaged Part[3]

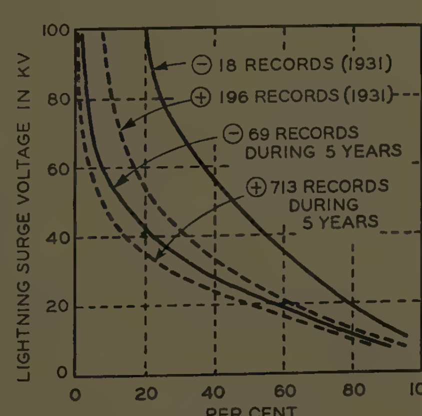
amaged Part	Number of Cases	Percentage
nary bushing	243	14
ondary bushing	18	1
d wire	587	34
nary winding	528	31
ondary winding	119	7
minal board	209	12
c.	7	0.4
ers	10	0.6
Total	1,718	100

able VI. Data on Lightning Arrester Discharge Currents, 1950

corded Discharge urrent, Amperes	Number of Records	Percentage
0- 100	29	43
101- 200	8	12
201- 300	12	18
301- 400	5	7.5
401- 500	3	4.5
501-1000	6	9
1001-2000	0	0
2001-3000	4	6
Total	67	100

lometers long, and the only line without overhead ground ires. Omitting the data for this unprotected line reduces e trouble rate for the remaining 721.1 kilometers to 1.4 ses per 100 kilometers.

On the 494.1 kilometers of 77-kv line there were 31 cases



gure 4. Primary stribution line lightng surge voltage expectancy curves

f lightning trouble or 6.3 cases per 100 kilometers. The amage included 352 broken insulators and 136 insulators hich had their surface color changed. Table I summarizes the service interruptions on the 77-kv and 154-kv nes for the years 1948, 1949, and 1950.

Damage to subtransmission and distribution systems has also been recorded. These systems are owned and operated by the Kansai Haiden K.K. Table II shows the cases of damage to generating stations, substations, subtransmission, distribution lines, and transformers for the years 1947 to 1950 inclusive. Table III summarizes the cases of damage on distribution systems, by months for the year 1947 to 1950 inclusive. Table IV summarizes the cases of damage on distribution systems by local areas, for the period January 1 to August 31, 1950. In Table V are summarized cases of damage to distribution transformers classified as to the damaged part. These data are for the year 1939, and were previously published.[3]

In order to prevent spreading of the disturbances, distribution feeders were de-energized at substations 265 times in the Kinki District on thunderstorm days in the summer of 1950. The mean duration of service interruption was 47 minutes, with an average energy interruption of 414 kilowatt-hours.

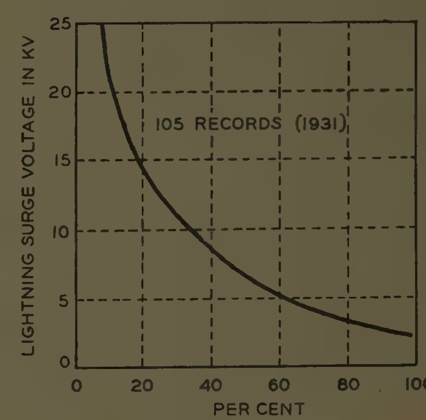


Figure 5. Secondary distribution line lightning surge voltage expectancy curves

Actual disturbances by lightning caused 264 feeder outages. The average duration of service interruption was 73 minutes and the average energy interrpution 1,950 kilowatt-hours.

Lightning discharge current through station lightning arresters was measured by magnetic links installed on 167 lightning arresters at 114 places, including generating stations and substations. Table VI gives the range of current recorded for the 67 records which were obtained in 1950.

In Figures 4 and 5 are reproduced some lightning surge voltage expectancy curves, which have been previously published.[4] Figure 4 is for primary distribution lines, and shows positive and negative surges for 1931 and for a period of 5 years. It is interesting to note the predominance of positive surges on these lines. Figure 5 gives similar data for secondary distribution lines taken during the year 1931.

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2. The Climatographic Atlas of Japan, 1948.

3. Denkikyodo-kenkyukai-iho, number 16, November 1939.

4. Denkikyodo-kenkyukai-iho, number 13, November 1937.

Economical Power-Line Terminal-Voltage Ratio

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MEMBER AIEE

THE PURPOSE OF this study was to determine the most economical terminal voltages to use on a 230-kv transmission line. To do this, annual transmission costs per unit of transmitted load were calculated and plotted as a function of receiver voltage. This was done for several sender voltages, receiver loads, line lengths, and so forth. The minimum points of the cost curves gave the most economical receiver voltage for the assumed conditions. The receiver-to-sender voltage ratio (only voltage magnitude is significant in this ratio) was determined for the minimum cost points. A plot then was made of terminal voltage ratio E_R/E_S versus receiver load for maximum economy; see Figure 1.

The only fixed costs included in this study were the cost of line and circuit breakers. The line construction consisted of one steel-reinforced aluminum cable per phase, each cable equivalent to 500,000 circular-mils of copper, and supported by approximately 31 tons of steel per mile on a 150-foot right-of-way. Line costs included interest on total investment, replacement on a 50-year life basis, operation, and maintenance. The annual costs of such a line was found from experience to be $1,680 per mile. Line lengths of 50 to 200 miles were investigated. The other fixed cost was that of two terminal circuit breakers. The circuit breakers considered were 230 kv, 7,500 megavolt-amperes with an estimated annual cost of $13,100 per circuit breaker.

The variable costs included the cost of losses (evaluated at $15 per kilowatt-year) and the cost of the necessary terminal reactive equipment.

Reactive generation was considered to be made up of either the sending-end generator overexcited, or a combination of 2/3 static capacitors and 1/3 synchronous condensers. When using the former (applicable only to new installation), only the increase in the basic generator cost was charged to the reactive. This gives a very low cost for reactive. The static capacitor-synchronous condenser combination costs approximately $0.70 per reactive kilovolt-ampere of capacity per year in the sizes used.

Reactors were used where required to maintain the specified voltages. No operating experience for reactors was available, but careful estimates placed their cost at $0.42 per year per kilovolt-ampere.

The transmission-line reactive requirements were considered to be satisfied in one of the following four manners (all receiving-end reactive requirements were satisfied by the static capacitor-synchronous condenser combination or the reactor in all cases): 1. same charge for the reactive required at either terminal; 2. no charge made for sending-end reactive; 3. charge only for the net reactive required; 4. charge for the sending-end reactive on the basis of increasing the generator size sufficiently to supply it in addition to the kilowatt load.

This study indicated that relatively high receiver voltages are more economical than low voltages. This means that reactive generating equipment can be purchased for the line and the saving in losses more than pays for the necessary equipment. For all assumptions investigated in this study, maximum voltages permitted by insulation stresses (242 kv for the 230-kv class) should be maintained for long lines heavily loaded.

Figure 1 shows a typical plot of terminal voltage ratio against load for maximum economy. This curve indicates that, for the specified assumptions, the receiver voltage should be at least 95 per cent of the sender voltage, and even greater for loads over 150 or under 100 megawatts. The other methods of charging for the sending-end reactive gave curves very similar to the curve shown with one exception. The exception was that of charging for the net reactive. In this case the voltage ratio for maximum economy was considerably higher than on the curve shown.

Unity load factor, rather than 0.75, was used to determine a set of curves. The curves comparable to Figure 1 except for load factor were nearly identical with those of Figure 1. This indicates that the conclusions reached may apply for a wide range of load factors.

A comparison also was made between curves based on public power costs and curves based on a typical set of private power costs. The curves resulting from the private power costs were nearly identical with those for public power costs. This does not mean that the costs were the same, but rather that with either set the best economy is realized from the same operating voltages.

On systems transmitting large blocks of power the operating terminal voltages should be viewed very critically from the standpoint of economy. The purchase of reactive generating equipment may prove a very wise investment.

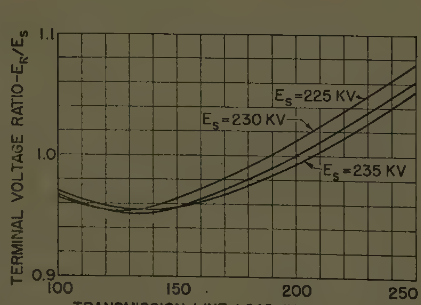

Figure 1. Terminal-voltage ratio versus line load for minimum annual cost. 1/3 terminal reactive requirements supplied by synchronous condensers and 2/3 by static capacitors. Line construction: 150-mile 230-kv class, one 795,000 circular-mil steel-reinforced aluminum cable per phase, and an equivalent spacing of 34 feet. Load is 0.75 load factor and is considered unity power factor with capacitors (or reactors) added in shunt to give the specified terminal voltages

Digest of paper 51-311, "Transmission-Line Terminal-Voltage Ratio for Best Economy," recommended by the AIEE Committee on Transmission and Distribution and approved by the AIEE Technical Program Committee for presentation at the AIEE Pacific General Meeting, Portland, Oreg., August 20–23, 1951. Not scheduled for publication in AIEE *Transactions*.

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Ignition Delay in Oil Burners

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MPROPER PERFORMANCE of gun-type oil burners operating with from 5 to 15 gallons of oil per hour led an investigation that pointed to ignition delay as the use of malfunctioning. The delay referred to is the time erval occurring between application of voltage to the ition transformer primary and the initiation of the spark charge in the spark gap.

A laboratory investigation of this delay phenomenon has en carried out using a standard domestic oil burner thout oil. Commercial nichrome electrodes 1/8 inch in meter adjusted for a 1/8-inch spacing were used. The ysical arrangement permitted automatic cycling of the burner for any desired on-off period with circuits so anged that the ignition transformer primary voltage uld be maintained at desired values and remain unected by the starting surge of the oil burner motor. ovisions were also made for measuring the open circuit ltage applied to the spark gap. One pen of a 2-pen ush oscillograph records the instant of application of ltage to the ignition transformer primary, while the cond pen records the incidence of spark discharge.

During the tests no attempt was made to control such tors as humidity, temperature, or barometric pressure, d these varied through the ranges to be expected during e period of testing from November 1949 to September 50. Voltage was applied simultaneously to the blower otor and ignition transformer primary and removed after e minute. A waiting period of varying length called e off-time was introduced between successive applications voltage. The blower, at normal speed, produced an air locity of approximately 50 feet per second. Gap spacing as maintained at 1/8 inch by checking at the beginning d end of each run of 100 trials.

Initial investigation had indicated that the delay exrienced was a function of the off-time. After many runs off-times of various values between 1 and 29 minutes, e data indicated that the off-time was not significant.

The data obtained are plotted for convenience on obability paper using delay-time as ordinate and cumutive per cent as abscissa. Figure 1 shows typical data. ach curve represents approximately 900 applications of ltage. Curve A shows the results for an ignition transrmer primary voltage of 115 volts (rated value), and curve shows the data for a primary voltage of 100 volts. The nificance of the data can be understood by noting that th the transformer operating at 115 volts, in 98 per cent the cases the delay was five seconds or less; and in 99.6 r cent of the cases, the delay was eight seconds or less.

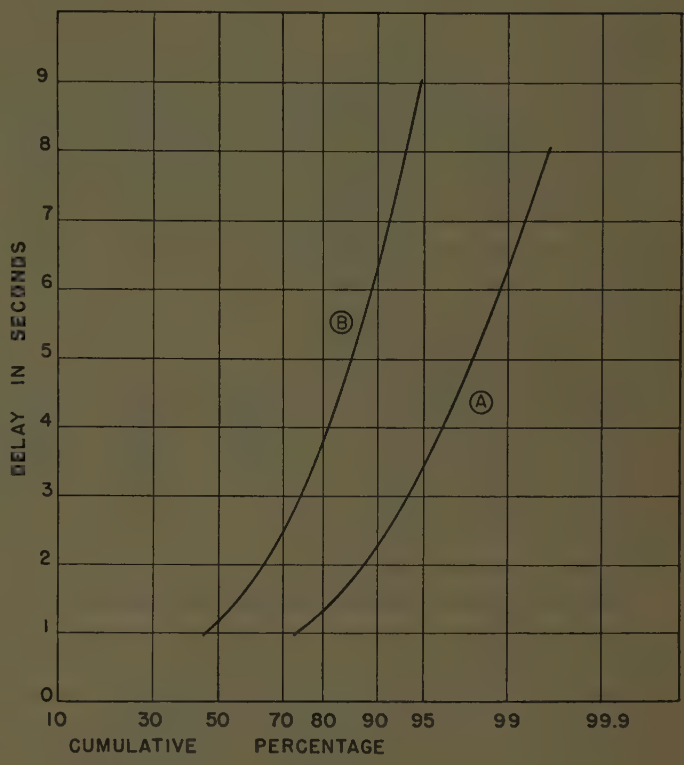

Figure 1. (A) Delay for primary voltage of 115 volts. (B) Delay for primary voltage of 100 volts

For 100 volts, in 86 per cent of the cases the delay was five seconds or less, and in 93.5 per cent 8 seconds or less.

Data also were obtained for voltages higher than those in use today. The data cited here for a primary voltage of 115 volts correspond to a secondary open circuit voltage of 10,368 volts rms, 14,661 volts peak. If the secondary voltage is increased by approximately 50 per cent, there results a tenfold decrease in delay.

A beginning was made in a study of the effect of the surface condition of the electrodes. The electrodes were polished to a mirror-like appearance and a series of runs, each consisting of 100 applications of voltage, was made. The delay became worse as the electrodes were fired, but soon the delay became less and even improved.

Irradiation of the spark gap was investigated, and virtually eliminated the delay problem. When the gap was irradiated from a neutron source producing approximately 500,000 ion-pairs per cubic centimeter, per second, per atmosphere in the vicinity of the gap, no delays exceeded 3/4 second; under the same condition without irradiation, 25 per cent of the delays exceeded 2 seconds.

In actual operation of burners in the field the difficulties experienced by delayed ignition have been cured by the use of a relay in series with the ignition transformer primary so connected that the blower and pump cannot start until ignition has taken place.

est of paper 51-320, "Ignition Delay in Oil Burners," recommended by the AIEE nmittee on Domestic and Commercial Applications and approved by the AIEE hnical Program Committee for presentation at the AIEE Fall General Meeting, veland, Ohio, October 22–26, 1951. Scheduled for publication in AIEE *Transns*, volume 70, 1951.

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Cable Sheath Problems and Design

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The wide variety of hazards to which Bell System cable sheaths are subjected imposes many design problems. This article describes the nature of these hazards and their effect on cable sheath engineering.

THE SHEATHS OF telephone cables provide the first line of defense against the whims of nature and of man for 70,000,000 circuit miles or 90 per cent of the Bell System's communication network. These 70,000,000 miles of circuit are covered with over 300,000 miles of cable sheath. The growth in the number of miles of cable and in the Bell System's investment in cable during the past 40 years (see Figure 1) is testimony to the importance of the cable sheath itself. The dependability of service to its customers and the protection of its investment go hand-in-hand in causing the Bell System to pay particular attention to cable sheath. The engineering of each cable installation is a complex problem in economics involving a satisfactory balance between costs and the quality of the service required of the circuits inside the sheath.

Recent developments in sheath design have tended to complicate the terminology concerning cable sheath. For this reason the following definition is given and is used throughout this article: everything outside the cable core is considered to be part of the cable sheath and consists of (1) a basic sheath only, or (2) a basic sheath and various protective coverings that may be applied over the basic sheath for the purpose of further safeguarding it. The sheath types that are now considered to be basic are shown in Figure 2.

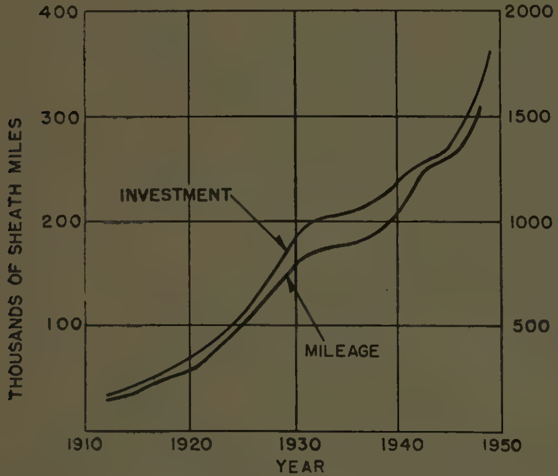

Figure 1. Bell System cable plant mileage and investment

Approximately 75 per cent of all Bell System cables are located in exchange areas and are covered only with a basic type of sheath. Protective coverings are applied over the basic sheath of all submarine cables, a substantial part of all toll cables, and some exchange area cables.

The worst enemy of paper-insulated cable is water. Particular care is employed at the factory to insure that the cable core of insulated conductors is dry before the basic sheath is applied. If the paper is allowed to absorb moisture the shunt conductance rises rapidly and the increase in attenuation that results can eventually put the circuit out of service.

There are several requirements which cable sheath must meet prior to installation. All cable sheath, for instance, must have sufficient flexibility and tensile strength to permit the cable to be placed on and removed from a reel of reasonable diameter several times without injury. Such rereeling is required when cable is being armoured or corrosion protected and when stock cable is to be shipped on orders for less than full reel lengths. Upon arrival at location the cable must then endure removal from the reel and the process of installation. From then on it must withstand the damaging influences that are peculiar to its particular location. An accurate evaluation and understanding of the hazards which beset every cable installation are mandatory if an average cable life of 30 to 40 years is to be achieved. The requirements placed upon a cable by its environment are very much dependent upon whether the cable is placed underground, on the ground, under water, or in the air. Underground cables may either be buried or placed in ducts.

The requirements placed upon cable sheaths by environment may be classed as mechanical, electrical, and corrosional. The mechanical requirements include tensile strength, resistance to abrasion, creep, bruising, and to fatigue caused by vibration and temperature changes. The electrical requirements are necessitated by lightning and the inductive interference effects of power lines. The corrosional requirements result from stray currents from electrified railway lines, earth currents, or from corrosive soil and duct conditions.

CABLE SHEATH PROBLEMS

THE MECHANICAL requirements of buried cable sheath would be rather severe if it were not for the fact that

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st buried telephone cables are covered with approxi-tely 30 inches of earth. This depth protects the cable m severe and sudden changes in temperature and is ficient to prevent wholesale damage by plows and small nd tools. Erosion in hilly terrain, however, can reduce terially the cable depth, and, in some cases, will com-tely expose the sheath. In locations of this sort the ath is subject to abrasion by rock movements caused freezing and thawing and to bruising by rock-falls and des. Also, in some sections of the United States, notably north central part, gophers have caused so much mage to cable sheath that special measures are taken ainst them.

Cable that is laid on the ground in gullies and dry shes must have sufficient tensile strength and sturdiness its sheath to resist the drag and pounding which it will eive during flash floods. Some cables must be installed rocky and rugged terrain that is inaccessible for normal tallation equipment. In those cases the cable must snaked into position with a wire rope; the sheaths olved must not only have considerable tensile strength

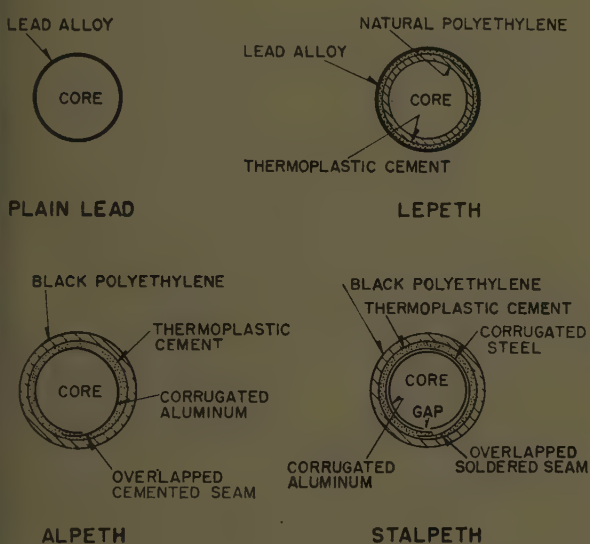


Figure 2. The four basic cable sheath designs

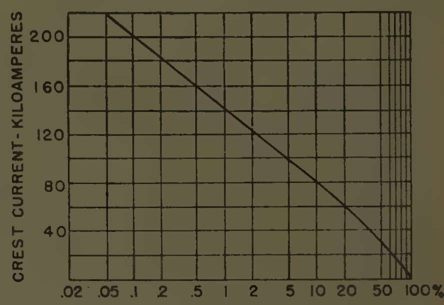
ut must also resist serious abrading and cutting forces uring installation.

The mechanical requirements of duct cable sheath are sually simple in that they only involve installation. The ble sheaths are well lubricated as they enter the ducts nd, except under adverse duct conditions, are subjected only minor abrasion during the pulling-in process. he sheath, however, must be able to withstand the rather vere bending and twisting incidental to splicing and cking in manholes.

Where aerial cable sheath is involved the mechanical quirements are focused mainly upon fatigue. Wind nd temperature changes cause the cable to swing and bow. he basic sheath materials, therefore, must be sufficiently sistant to fatigue from these sources. Damage to aerial ble occasionally results from stray bullets from small ms, flying stones from blasting operations, and objects cast by small boys. Even the lowly fishhook has taken its toll.

The list of mechanical requirements for submarine cables includes tensile strength, abrasion resistance, and stiffness. Great tensile strength is required because

Figure 3. Percentage of lightning strokes to buried structures in which current exceeds ordinate



irregularities in submarine topography may leave long spans of cable unsupported and because large dragging forces are created by tides and, now and then, by anchors of ships. Vibration fatigue is important where fast tides cause the cable to be in almost constant motion.

The damaging aspects of lightning to cable take two forms in that the current can burn holes in the sheath and can arc from the sheath to the inside of the cable. Holes in the sheath can cause eventual circuit failure by allowing the ingress of water, the carbonized products of burned insulation can produce immediate outages, and in severe cases of damage actual fusing of the conductors may occur.

The important characteristics of lightning itself include the current amplitude and wave shape of the stroke and its frequency of occurrence. The current[1] of the average stroke has been found to reach its crest value in 5 to 10 microseconds and to drop to half of its maximum value in 70 microseconds. The possibility of damage to a cable depends upon the magnitude of the peak current; the severity of the damage is related to the energy content in the wave following the peak. The crest currents of lightning discharges vary over a wide range, see Figure 3. The number of thunderstorm days per year varies extensively throughout the United States and is shown in Figure 4. Field studies extending over a number of years have shown that the number of strokes to earth per square mile per thunderstorm day ranges from 0.28 in northern to 0.43 in some southern parts of the country.

An aerial cable will attract all the strokes along a zone whose width is about seven times the height of the cable above the ground,[2] and hence the average number of strokes per year to an aerial cable can be computed readily. For a buried cable the width of the zone of attraction in feet ranges from 1.4 to 2.4 times the square root of the earth resistivity in meter-ohms. The 1.4 applies for resistivities in excess of 1,000 meter-ohms and the 2.4 is for resistivities less than 100 meter-ohms. From these figures it can be seen that an aerial cable 25 feet high will collect four times as many strokes as a buried cable where the soil resistivity is 1,000 meter-ohms. The presence of trees, power lines, buildings, water towers, and so forth, along the cable route causes a marked reduction in the effective

width of the lightning zone of an aerial cable, but has little effect on that of buried cable. However, buried and duct cable are given considerable protection by water pipes and other conducting structures along the line of the cable.

After the number of strokes per year to a cable has been estimated, the next step is to determine the number of

Figure 4. Map showing average number of thunderstorms per year

those strokes that will have sufficient peak current to damage the cable. For buried cable this maximum allowable crest current, I_m, in kiloamperes is approximately equal to

$$I_m = \frac{0.31 V_c}{R\sqrt{\rho}}$$

where V_c is the impulse rating in kilovolts of core-to-sheath dielectric; R is the d-c resistance of sheath in ohms per mile; and ρ is the earth resistivity in meter-ohms. The number of faults per year, N, on the length, l, of buried cable can now be obtained from

$$N = an/100$$

where a is the per cent obtained from Figure 3 using I_m for the ordinate value; and n is the probable number of strokes collected by buried cable in one year.

The situation is more complicated for aerial cables[2] because the current can flash over to ground at guy wires, pole protection wires, and so forth.

The resistance of the cable sheath and the impulse breakdown voltage of the core-to-sheath insulation are the only controllable features which are an integral part of the cable itself.

There are two aspects to the induction problem. One concerns the normal operating condition of the power line while the other is associated with the abnormally large currents when a fault occurs. Both of these aspects are fundamentally the same although they manifest themselves in rather different ways in their effect on cable circuits. Under normal operating conditions noise can be introduced into the cable circuits by the fundamental and harmonics of the power frequency. When sufficiently high, induced voltages can render signaling circuits inoperative and noise can impair the intelligibility of talking circuits. Fault currents induce voltages from conductor to sheath, sheath to ground, and across the ends of an opened conductor which may be dangerous to personnel working on the cable. In addition, these high induced voltages can cause protectors on the cable conductors to operate and thereby ground the conductors either momentarily or permanently.

The layer of metal in all basic cable sheath provides an almost perfect shield against electric fields and reduces the deleterious effect of magnetic fields. The magnetic shielding comes about because the power line current induces voltage in the metallic shield. The resulting current sets up a magnetic field of its own in opposition to that of the power line current. The d-c resistance of the sheath, therefore plays a predominant part in the determination of the magnetic shielding and should be as low as practicable. This requirement is in entire agreement with that presented by the lightning problem.

Other variables involved in the amount of magnetic shielding are frequency, the impedance of ground connections, the earth resistivity, the leakance of the sheath to earth, and so forth. When magnetic materials such as steel tapes are used as part of the sheath, the shielding also depends upon the amount of induced current in the shield and the permeability, diameter, number, thickness, width, angle of spiral, and air gap between turns of the steel tapes.

The corrosion problem results from the various electrochemical phenomena that can be present when:

1. Dissimilar metals are conductively connected together and immersed in an electrolyte.
2. A given metal is immersed in dissimilar electrolytes that are conductively connected.
3. Stray currents from d-c systems enter or leave the sheath via an electrolyte.
4. The electrolyte is chemically active with regard to the metal.

The currents involved may be man-made, such as stray trolley currents, or may be caused by self-generated voltages that are established in accordance with the electromotive series and the nature of the electrolyte in which the cable is immersed.

Duct and buried cables are far more subject to corrosion than are aerial cables. Normal atmospheric conditions usually keep aerial cables dry. Duct and buried cables however, are frequently exposed to at least one or more of the conditions outlined.

The part that the cable sheath can play in the reduction [of] corrosion is to minimize the reaction of its metallic parts [wi]th electrolytes and metallic structures. From the corro[sio]n problem standpoint the insulation resistance of the [sh]eath to ground should be high enough to limit current [de]nsities to safe values.

CABLE SHEATH DESIGNS

Plain Lead. As its name implies, this is simply a sheathing [of] lead which is extruded over the cable core. While the [sh]eath is broadly referred to in most cases as lead, it is in [re]ality a lead alloy. Pure lead is inferior to some of the [al]loys from a fatigue standpoint and therefore is not recom[m]ended for aerial use. Small or fractional percentages [of] tin, calcium, silver, and zinc have been alloyed with [le]ad with reasonable success but for all-around service [1] per cent antimony alloyed with 99 per cent lead is now [m]ost generally used.

Lead sheath alone provides sufficient mechanical pro[te]ction for most aerial and duct installations and is likewise [a]n effective moisture barrier. Its conductivity in combi[na]tion with the dielectric strength provided by the con[d]uctor insulation and core wrap is sufficient to prevent [e]xcessive lightning failures in most duct installations and [i]n aerial installations except where very small cables are [in]volved in areas where lightning storms are prevalent. [F]rom the standpoint of low-frequency induction the lead [sh]eath when properly grounded is reasonably effective as a [s]hield and of substantial benefit in reducing noise in the [t]elephone circuits. From the corrosion standpoint lead is [sa]tisfactory in dry surroundings but susceptible to corrosion [i]n a wet environment if stray electric currents or corrosive [s]oil conditions exist. Lead is very adaptable to forming [d]uring the installation operations. Also, the sheath [in]tegrity is made continuous across a splice by hot-wiping [a] lead sleeve directly to the lead sheath.

Alpeth and Stalpeth Sheath. Alpeth sheath, which is shown [i]n Figure 2, consists of an 0.008-inch aluminum tape [a]pplied longitudinally with overlap and an extruded [p]olyethylene outer jacket. The seam in the aluminum is [fi]lled with a polyisobutylene cement, and a flooding of [r]ubber thermoplastic cement applied over the aluminum [f]orms a bond between the aluminum and polyethylene.

This sheath is a postwar development. The scarcity [o]f lead, lead controls, and high lead price all pointed out [t]he importance of having a substitute sheath available, and [i]f possible a more economical one. The problem was not [a]n easy one, however, as all materials used would have to [b]e in plentiful supply and at a reasonable cost. Also [a]ny sheath developed would have to fulfill to a reasonable [d]egree all the obligations discussed for lead sheath.

Investigation of materials and application techniques [i]ndicated that metals or metal alloys were not particularly [p]romising. Development of plastics during the war years, [h]owever, had proceeded at a rapid rate and there were [s]everal that showed promise. Plastics, in contrast to [m]etals, permit passage of moisture and in this respect [p]olyethylene appeared to be the most logical choice since [i]ts diffusion constant is lower than other commercially [a]vailable plastics. The mechanical characteristics of polyethylene are likewise excellent. It is tough, abrasion resistant, and can be extruded readily at temperatures in the range of 300 to 500 degrees Fahrenheit. It does not become brittle until temperatures well below those normally encountered in the field are reached and continued flexing or vibration does not appear to produce the fatigue effect found in metals.

These characteristics are all excellent, but degradation of the polymer will take place if it is exposed to sunlight. Bell Telephone Laboratories' chemists found, however, that very great improvement in aging characteristics could be achieved by thoroughly dispersing 2 per cent finely divided carbon black in the polyethylene.[3] An antioxidant also is added to the compound to protect it during processing and to improve its aging characteristics.

The polyethylene alone, however, could not fulfill all of the requirements of a sheath as the amount of moisture which would diffuse through any jacket of reasonable thickness would be intolerable and the cable would have essentially no protection against lightning or inductive interference. A metal was needed, therefore, and the field was readily narrowed to copper and aluminum with aluminum being chosen because of lower cost.

The thickness of the tape decided upon was 8 mils, which represents a compromise between electrical and mechanical considerations. To obtain the most moisture-proof seam and maximum longitudinal conductivity, the tape was applied longitudinally with an overlapped seam which could be sealed with cement. Such a tube, however, is not sufficiently flexible except for core diameters below approximately 0.60 inch, so a means of adding flexibility to this structure for the larger cables was needed. This was accomplished by precorrugating the aluminum tape at right angles to its length before forming. With approximately sine-wave shape and 10 corrugations per inch sufficient material is stored up to give excellent flexibility to the completed sheath. To further improve the moisture resisting properties the aluminum envelope is flooded with thermoplastic cement which also adheres to the polyethylene outer jacket.

The completed alpeth sheath provides good mechanical protection and its lightning protective and inductive shielding qualities are adequate for most situations. In fatigue it is better than lead and the polyethylene jacket is a corrosion resistant covering. The lighter weight of alpeth sheath permits the use of longer spans. From a moisture barrier standpoint it is inferior to lead in service but even in this regard its life should be adequate.

As with any new product there were many problems. Lead splicing sleeves readily can be wiped to lead cable but obviously cannot be joined as easily to alpeth. An effective type of sheath splice has been developed but at the present time this joint must be accomplished by using adhesive materials and a fairly complicated technique which increases the cost of the splice.

Many minor problems were encountered and solved but a major trouble also developed which threatened the very life of alpeth cable. About six months after production began, field reports started coming in to the effect that the polyethylene sheath had cracked near the splice or that

cracks had been found after removing a cable which would not hold gas. The first reaction was that the failures were due to structural weakness of the polyethylene and test cables were subjected to all manner of extreme handling, which only emphasized the toughness and strength of the jacket.

After many blind alleys had been explored it was found that certain agents, which will be referred to as contami-

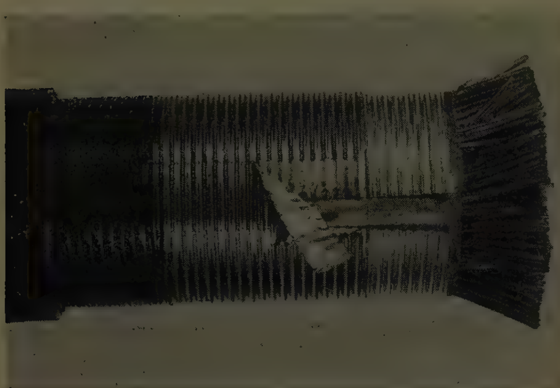


Figure 5. Stalpeth cable showing corrugated steel and aluminum

nants, would cause polyethylene to crack under reasonably mild strain conditions.[4] Among the most active of these surface contaminants are detergents and soaps. Since splices often are pressurized and tested for gas leaks with a liquid soap solution and a compound consisting largely of soap was used in certain areas as a duct lubricant, it is not surprising that failures were reported from the field.

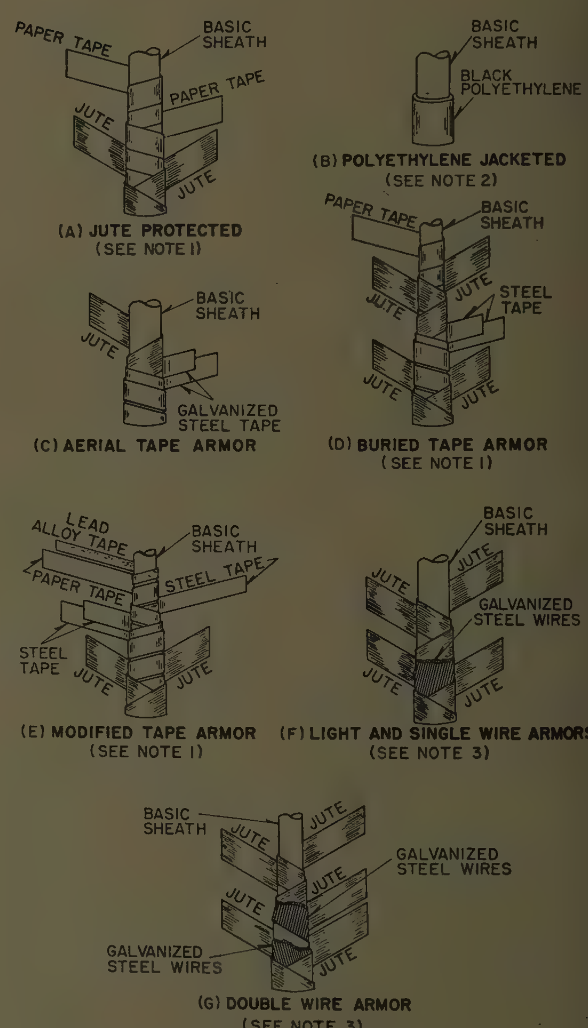
All known contaminants were banned immediately, and new types of pressure testing solutions and duct lubricants were developed and put into use. The most important goal was, however, to obtain a polyethylene which is crackproof. This project has not been completed but great improvement has already been obtained mainly through increasing the average molecular weight of the polymer. Laboratory tests now indicate that the most active contaminants will not crack the present alpeth jacket even at strains far beyond any to be found in the field.

Engineers then attacked the problem of improving the moisture resistance and lowering the high splicing cost inherent with the present type splice used for alpeth cable. The result is a modification of alpeth sheath and is called stalpeth. In this construction, which is shown schematically in Figure 2 and as a photograph in Figure 5, there is a corrugated 0.008-inch aluminum tape applied longitudinally with slight gap. There is then a corrugated 0.005-inch terne coated steel tape applied longitudinally with a soldered overlap. The steel is flooded with thermoplastic cement and over this is applied a polyethylene jacket.

Soldering is the critical operation in producing this design. A flat solder strip is fed into the overlap in the corrugated steel just after forming, and immediately thereafter the cable passes underneath the work coil of an induction heater. With steel, soldering can be accomplished with 4 to 5 kva with a line speed of 50 feet per minute.

Stalpeth, which in time will replace alpeth, is essentially moistureproof. The initial cost is roughly the same as alpeth since it is practicable to reduce the thickness of the polyethylene jacket, and splicing costs should be considerably lower since the steel jacket furnishes a surface to which lead sleeves can be joined by the wiping technique. Although for the time being stalpeth will only be applied at the plants manufacturing exchange area cable, there is no basic reason why this type of sheath could not be used for toll cable, except where lightning is a problem, if the relative supply or price of polyethylene with respect to lead made this desirable.

Lepeth Sheath. The basic sheath design for lightning protection is called "lepeth" sheath. This design, as shown in Figure 2, consists of a 75-mil layer of polyethylene surrounded by a layer of lead. A flooding of thermoplastic cement is applied between the polyethylene and lead layers.



NOTES:

1. BASIC SHEATH AND EACH LAYER FLOODED WITH ASPHALT COMPOUND. COATING OF WHITING APPLIED TO FINISHED CABLE.
2. BASIC SHEATH FLOODED WITH THERMOPLASTIC CEMENT.
3. EACH LAYER PROTECTION FLOODED WITH ASPHALT COMPOUND. COATING OF WHITING APPLIED TO FINISHED CABLE.

Figure 6. Protective covering designs for cables

The 75-mil layer of polyethylene is tested at the factory 3 seconds at 20,000 volts d-c and has an impulse voltage eakdown rating of 30,000 volts. This high impulse ltage rating and the low resistance of the lead covering ovide excellent electrical protection against lightning. r example, a buried lepeth cable with a core diameter of 57 inches has a sheath resistance of approximately 1.5 ms per mile. When installed in soil that has a resistivity ual to or less than 1,800 meter-ohms the sheath will be ctrically immune to strokes that place less than 150,000 peres on the sheath. In localities where the number of understorm days per year does not exceed 50, the probability of failure due to lightning would be approximately e or less failure per year per 1,000 miles of sheath.

COVERINGS FOR BASIC CABLE SHEATH

Jute Protected. Buried cables with plain lead or lepeth sic sheaths may be jute protected. This design, Figure 1, is relatively inexpensive and provides good protection ainst the hazards of the plowing-in operation. It is ed where corrosion, power line interference, gophers, d mechanical damage risks do not present special oblems. The paper, asphalt, and jute covering over e basic sheath do not offer any protection against lighting in addition to that provided by the basic sheath.

Polyethylene Jacketed. The polyethylene jacket type of otection covering is used at present only in duct installaons where corrosion problems are present. This design, igure 6*B*, gives excellent corrosion protection to the lead nder the polyethylene because the resistivity of polythylene is very high even when immersed. The polythylene covering is tough and is scuff resistant; its smooth rface allows the cable to be pulled into ducts with ease.

Steel Tape Armored. Aerial and buried cables with plain ad or lepeth basic sheath may be tape armored. The erial design, Figure 6*C*, consists of a layer of jute and two yers of galvanized steel tapes. The buried design, igure 6*D*, is made up of a layer of paper over the basic heath, two layers of jute, two layers of steel tape, and two ore layers of jute; the basic sheath and each layer of rotection are flooded with an asphalt compound and a oating of whiting is applied to the finished cable. No sphalt compound is used in the aerial design because orrosion protection usually is not needed and because the sphalt would slowly drip from the cable and create a ublic nuisance.

The buried design is susceptible to lightning damage a way that is rather curious. The jute, paper, and sphalt applied between the lead and the steel tapes act s an insulator between them. Lightning currents may rc from the steel tapes through this insulation to the lead. The explosion products produced by this arc create a igh pressure gas pocket between the lead and the steel apes which can collapse or flatten the cable at the point f entry of the stroke. This problem is especially serious here the essentially hollow tubes of coaxials are involved.

To circumvent this lightning problem a modified form f tape armor was developed for buried cables. This esign, Figure 6*E*, consists of a layer of alternate lead alloy and paper tapes, three layers of steel tape, and two layers of jute. The basic sheath and each layer of protection are flooded with an asphalt compound and a coating of whiting is applied to the finished cable.

This modified design of tape armor replaced the previously described design for all buried toll cables exposed to lightning, and derives its advantage from the fact that the lead tape allows lightning current to travel from the steel tapes to the lead sheath without arcing.

Figure 7. Cross-sectional view of double wire armored cable

Light Wire Armored. The tensile strength and abrasion resistance of the armor wires used by this design, Figure 6*F*, allow it to be used in a variety of places. Light wire armored cable can be laid over rocky terrain that is not plowable, and can be snaked into locations, such as swamps and very rugged terrain, that are inaccessible to cable installation equipment. It also can be used as buried cable across gulleys or other places where erosion is likely to expose the cable and leave unsupported lengths. This protective design is employed also for crossings of reservoirs and shallow lakes and streams where navigation is restricted to canoes, rowboats, and launches.

Single and Double Wire Armored. The single wire armored design employs heavier armor wires and thicker lead sheath than the light wire armored design; these are the only differences between the two. The double wire armored design is shown in Figures 6*G* and 7.

Both of these designs are intended for submarine use. Single wire armored cables are employed in deep lakes, across navigable streams, and in coastal waters, including estuaries, bays, and inlets. Double wire armoring is for use under unusually severe submarine conditions such as locations having fast tides and rocky irregular bottoms.

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Analysis of 3-Phase Inverter with Resistive Load

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ALTHOUGH GAS-TUBE INVERTERS have had only moderate use in the past, they have potentialities of far wider applications in many fields. Possible applications include use of inverters to supply power to induction and synchronous motors, use of inverters at the receiving end of a d-c transmission line, and use of inverters in electric railway systems to allow power to flow from the d-c system to the a-c supply. Certain polyphase circuits have been designed primarily for operation at a fixed-frequency or over a limited-frequency range. If operation of polyphase inverters can be extended down to zero frequency, inverters may be able to supply variable-frequency power to polyphase induction and synchronous motors, thereby providing continuously variable speed from zero to full speed in either direction. An inverter circuit capable of this type of operation is the 3-phase bridge-type inverter which is commutated by capacitors connected across the output terminals of the inverter, as shown in Figure 1.

When this inverter is operated over a wide range of frequencies, the output-voltage waveforms are far from sinusoidal. If the input current is assumed constant at a value I, the output-voltage waveforms can be calculated readily. A set of normalized waveforms for various values of load is shown in Figure 2. In the figure the time scale t and the load-network time constant $\tau=3RC$ have been normalized with respect to the grid excitation frequency f, and the voltage between nodes a and b, v_{ab}, has been normalized with respect to $E=2IR$.

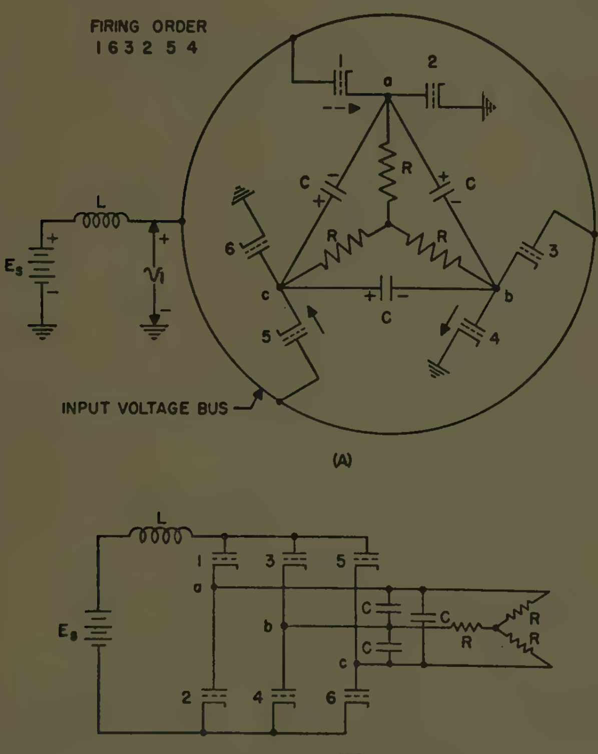

Figure 1. Three-phase inverter with resistive load

There are two principle disadvantages to the inverter shown in Figure 1 aside from the nonsinusoidal output-voltage waveform. The first is that the firing system and

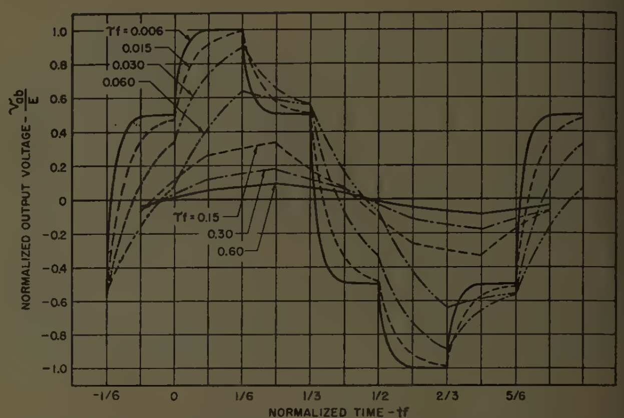

Figure 2. Normalized output-voltage waveforms for various values of the load-network time constant

the commutation system must be very reliable, for the failure of a tube to be fired or extinguished at the proper time may cause two tubes in the same phase (tubes one and two in phase a, for example) to conduct simultaneously and form a short circuit across the d-c source.

The second disadvantage is that proper operation of the inverter requires that negative reactive power be drawn from the load, necessitating a leading power-factor load. When a resistive load is placed upon a capacitor-commutated inverter, the capacitors supply the required reactive power to the inverter. There is no difficulty in obtaining leading power-factor loads in this case, and the experimental inverter operates properly over a frequency range extending down to zero for various values of load. When the inverter is supplying an inductive load, however, the capacitors must be large enough to cause the load seen by the inverter to be capacitively reactive. This requirement is difficult to fulfill when low-frequency operation is attempted with inductive loads. Brief experimentation with an induction motor load indicated that satisfactory variable-speed operation could be obtained for frequencies down to about 12 cycles per second. Below this frequency commutation difficulties frequently were encountered which were caused, in part, by the lack of a leading power-factor load.

Digest of paper 51-210, "Analysis of the Three-Phase Inverter with Resistive Load," recommended by the AIEE Committee on Electronic Power Converters and approved by the AIEE Technical Program Committee for presentation at the AIEE Summer General Meeting, Toronto, Ontario, Canada, June 25–29, 1951. Scheduled for publication in AIEE *Transactions*, volume 70, 1951.

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Current Transformers Near High-Current Busses

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WHEN CURRENT TRANSFORMERS are applied in the vicinity of busses carrying large currents, the [tra]nsformer accuracy may be very seriously affected. This [is] particularly true on systems which normally carry over [1,]000 amperes and may carry 10 or 20 times this current [du]ring faults. A current transformer designed to operate [pr]otective relays during such a fault may be rendered [co]mpletely useless by improper installation. For instance, [Fi]gure 1 gives the accuracy of a certain current transformer [wi]th the primary return conductor at several different [sp]acings.

If a burden of 0.190 ohm were used, and a return spacing [of] 12 inches, saturation would occur at about 10,000 [am]peres. However, with the same burden and a return [sp]acing of 6 inches, saturation would occur at only 6,000 [am]peres. This could mean the difference between relays

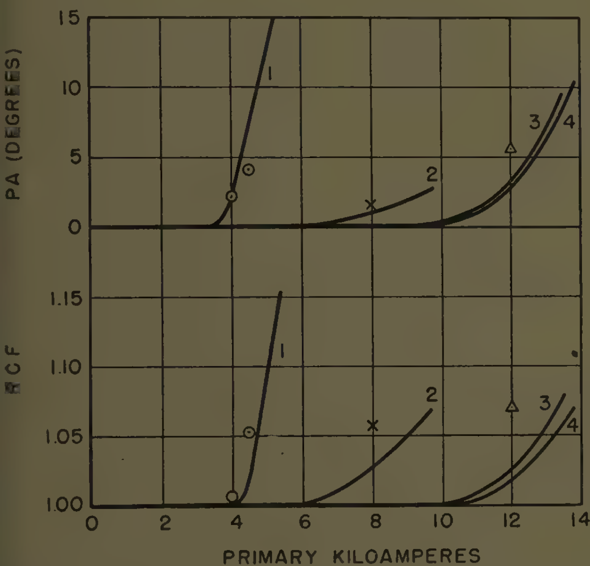

Figure 1. Overcurrent accuracy of transformer number 3

[T]ested Curve	Calculated Points	Connected Burden	Return Spacing, Inches
1	○	0.790+j0	6
2	×	0.190+j0	6
3	△	0.190+j0	12
4		0.190+j0	24

[o]perating properly and relays not operating at all. Be[c]ause such operating conditions are difficult to reproduce [in] test, it is usually necessary to rely on calculated rather [th]an tested accuracy when such a situation is encountered. [A] current transformer which is being subjected to inter[fe]rence flux from an adjacent conductor presents the same problem of accuracy calculation as a transformer with internal leakage.

Considering a ring-core current transformer with single-bar primary, the flux in the core due to the adjacent conductor current may be found from Figure 2. R is the

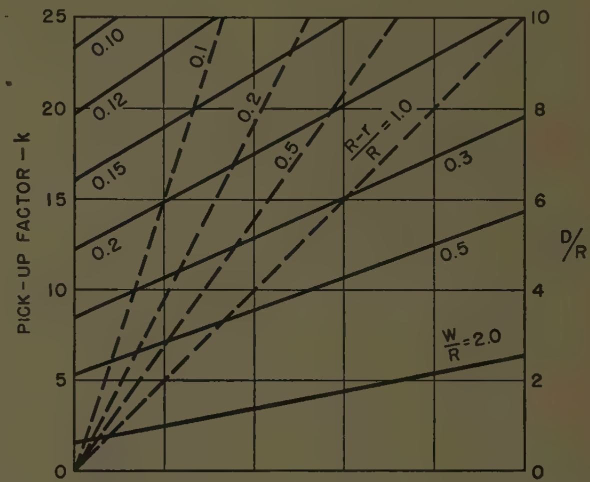

Figure 2. Core pickup factor: enter with D/R; horizontally to R-r/R; vertically to W/R; horizontally to k

outside radius of the core, r is the inside radius of the core, W is the width of the core, D is the distance from the center of the primary conductor to the center of the adjacent conductor, and k is the ratio of the actual flux entering the core to that which would have entered a nonmagnetic core of the same dimensions.

If the calculations are made by determining the primary current necessary to produce an assumed secondary current, the stray flux may be assumed to divide in the core in such a manner as to induce zero voltage in the secondary winding.

Several calculated accuracy points are included in Figure 1 to give an idea of the comparison between calculated and tested results.

It should be noted that when calculations are made in the region where the core iron is saturating, very small errors in density produce very large changes in calculated accuracy. This means that calculated accuracy cannot be expected to check tested accuracy closely if the transformer errors are large. Usually the point where the errors start to increase rapidly can be calculated with reasonable accuracy, but no attempt is made to carry the curve further.

Digest of paper 51-308, "The Accuracy of Current Transformers Adjacent to High-Current Busses," recommended by the AIEE Committee on Instruments and Measurements and approved by the AIEE Technical Program Committee for presentation at the AIEE Pacific General Meeting, Portland, Oreg., August 20–23, 1951. Scheduled for publication in AIEE *Transactions*, volume 70, 1951.

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Factors in Transmission Line Design Related to Conductor Vibration

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Vibration of conductors is an important factor in transmission line design. Just how important is the subject of this article, which describes the Los Angeles Department of Water and Power's efforts to mitigate the effects of vibration by lessening line tension and improving design of clamps and splices, and actual operating experience with vibration in the Department's line from Boulder Dam.

IN WIND TUNNEL experiments conducted a number of years ago, the Los Angeles Department of Water and Power found that a span of cable, at a fixed tension between supports, could be made to vibrate in any whole number of loops of equal length simply by adjusting the wind velocity and its related air eddy frequency. The vibration amplitude was constant when the air eddy frequency was close to the resonant frequency of the conductor; it contained a beat note which varied periodically if the air eddy frequency was midway between two resonant frequencies of the conductor.

Since loops of various lengths were being obtained in the several tests, over-all amplitude measurements made at the center of the loop were not in themselves representative of the severity of bending. It was necessary and convenient to express results in terms of the total angle through which the cable moved at the node point, calculated by assuming that the vibrating cable takes the form of a sine wave. The equation relating total angle of bending, amplitude at the center of the loop, and loop length is easily derived, and may be expressed

$$\theta = 0.262\ A/L$$

where θ = total angle of bending, in radians, A = over-all amplitude in inches at the center of the loop, and L = loop length in feet. Table I illustrates the conditions found in the case of one type of conductor tested.

This and other tests in which the tension was varied showed that, as tension was increased, the range of wind velocities which produced vibrations at the various loop lengths also increased the severity of the bending. The data in Table I, taken from tests on a copper conductor, show that winds from 1.88 miles per hour up to 6 miles per hour can cause more bending in the cable if the tension is increased from 4,000 pounds to 6,000 pounds. Thus, higher tensions not only encourage higher frequency vibration and a greater number of fatigue cycles per unit time but also may result in more flexure of the cable on each cycle. Although the tests were not applied to a wide variety of conductors, nor to steel ground wires, other types of cables will likely show the same effects with tension. For this reason serious efforts have been made to keep the tensions as low as practicable on all Department transmission lines.

EFFECT OF DESIGN TENSION ON COSTS

CAREFUL INVESTIGATION of the effects of conductor tensions on the cost of steel tower transmission lines has indicated that there is no real justification for the higher line tensions, where tower lines are designed for broken wire conditions. The method of investigation and the results obtained were reported at the recent International Conference on Large Electric High-Tension Systems (CIGRE) in Paris.[1] A summary of the findings would include the fact that, although high tensions permit lower or fewer towers, each such tower must be appreciably heavier to withstand the unbalanced pulls imposed by broken wire conditions. This increased weight per tower adds steel costs which more than offset the cost of additional lighter towers that would be used with lower design tensions, even though the latter involves additional costs for footings, hardware, and insulators.

After determining the quantitative effect of conductor tension on line costs, it was found to be not only practicable to use fairly low conductor and ground-wire tensions but also economical. For example, in the design of a 258-mile 230-kv single-circuit steel-tower line which the Department now has under construction, economy dictated the use of a 954,000-circular mil steel-reinforced aluminum cable in 1,100-foot spans at a normal tension of 4,600 pounds at 60 degrees Fahrenheit and a maximum tension of 10,000 pounds with ice and wind loading. The rated strength of the conductor is over 34,000 pounds, but an uneconomical use of tower steel was discovered above 12,000 pounds maximum tension, and below 10,000 pounds. Of these two tensions, the lower was selected with vibration considerations in mind.

The use of higher conductor tensions is accompanied not only by transmission line cost penalties but also by increased vibration stresses and opportunities for vibration fatigue. Vibration dampers and armor rods for prolonging cable life can be a necessity under these circumstances, but a necessity of unknown degree. The margin of safety

Essential text of a conference paper, "Factors in Transmission Line Design Related to Conductor Vibration," recommended by the AIEE Committee on Transmission and Distribution and presented at the AIEE Fall General Meeting, Oklahoma City, Okla., October 23–27, 1950.

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Table I. Wind Tunnel Vibration Test

sion, unds	Number of Loops	Loop Length, Feet	Frequency, Cycles per Second	Wind Velocity, Miles per Hour	Total Angle of Bending, Radians
940	5	12.4	14.3	6.10	0.0027
	4	15.5	11.4	4.89	0.0029
	3	20.7	8.6	3.52	0.0038
	2	31.0	5.7	2.43	0.0069
980	5	12.4	13.0		0.0025
	4	15.5	10.4	4.47	0.0026
	3	20.7	7.8	3.24	0.0031
	2	31.0	5.2	2.19	0.0055
020	5	12.4	12.0	4.6	0.0020
	4	15.5	9.6	3.87	0.0021
	3	20.7	7.2	2.85	0.0024
	2	31.0	4.8	1.88	0.0041

se devices afford in such a case is therefore somewhat leterminate. Relatively lower tensions will reduce e costs and opportunities for vibration fatigue will be sened. It is possible that dampers or armor rods might t be required, but they may be installed to provide a argin of safety which, under the improved circumstances, ay be a very material one.

Armor rods and Stockbridge vibration dampers are ing installed at all supports on the Department's new 0-kv line to provide this margin of safety.

In the case of ground wires, it is usually necessary to aintain a fixed minimum mid-span separation between ese shield wires and the conductors. A choice of high nsions and short ground-wire horns at the towers is e possibility, and low tensions with high ground-wire achment horns is another. Again, if tower economics is nsidered, and if broken wire contingencies are included the design, lower ground-wire tensions will be favorable lower costs. Lower towers, and higher tensions, produce large or larger moments on the tower with the unlanced pulls accompanying broken wires as will higher wer attachments and lower tensions.

On the Department's Boulder Dam transmission lines 2-inch extra-high-strength galvanized steel strand having breaking strength of in excess of 18,000 pounds is used for ound wires on the single-circuit sections, and normal nsion at 60 degrees Fahrenheit is 1,800 pounds. The -foot mid-span separation required between conductors d overhead wires made it necessary to attach the ground res to a point slightly more than 19 feet above the sulator string attachment point on the crossarm.

The new 230-kv line now under construction is being ielded with the same extra-high-strength wire, and a rmal tension of 2,100 pounds at 60 degrees Fahrenheit is ing used over the 245-mile length where single-circuit nstruction is employed.

No vibration dampers have ever been installed on any erhead ground wires of the Department's transmission es, and to date there has been no reason to consider eir use.

SUPPORTING AND SPLICING OF CONDUCTORS

DESCRIPTIONS OF THE hardware for supporting the 1.4-inch diameter 512,000-circular mil Hedernheim-pe copper conductor on the 287.5-kv transmission lines Hoover Dam have been furnished previously.[2,3] In brief, vibration tests showed the advantage of and necessity for careful design of the suspension clamps used with the conductor. All principal dimensions of the clamp parts were determined by special tests, including such things as location of trunnion points, saddle pivots, curvature of saddles in both directions, length of saddles, and the dimensions of the parts of the center wedge system.

In the splices for the conductor, it was essential to design for light weight and comparatively short length. The reason for this was that the splice in the conductor, by virtue of its additional weight, would establish a node point in the vibrating cable, and a light, concentrated weight would be more able to "rock" and follow the frequency of vibration if its moment of inertia were kept as low as possible. This design reduced to a minimum the bending which would occur at the edge of the splice. Also highly important was the control of the shear diagram representing the wedge pressures of the splice on the cable. For long cable life the shear diagram should have a uniform taper from the edge of the splice back into the body so that no initial high clamping action could occur on the conductor at the extreme edge of the splice. The same splice design was used at the strain towers, a threaded socket eye being used to dead-end the conductor by replacing one of the two splicing sleeves normally used in making a line splice.

In the case of the ground wire strain clamps a "ram's horn" design was used, and as much of the clamp mass as possible was held close to the tower attachment point to reduce the moment of inertia and enable the strain clamp to "follow" the convolutions of the cable. The suspension clamps were of the trunnion type to allow the free travel of vibration from one span to the next and minimize the bending at the support.

DETERMINATION OF PROBABLE CONDUCTOR LIFE

THOUGH ALL OF THE mechanical considerations were given due attention, the most important consideration was whether or not the cable would have a 50-year life in service. This period was chosen because it represented the life of the contract for energy from Hoover Dam.

To gain some insight into the probable life of the conductor, long samples of the Hedernheim-type cable were vibrated to destruction in the laboratory, and the process was repeated numerous times, using smaller amplitudes of vibration for each successive test. By this means a vibration intensity life curve was established. Simultaneously, records of the amplitude, frequency, and duration of cable vibration were made under actual field conditions of wind, using full-scale towers and 1,000-foot span lengths in locations having wind conditions most conducive to conductor vibration. It was believed that if field records of this type could be gathered for a period of time long enough to be representative of the wind conditions which would be experienced by the conductor for a period of several decades, the correlation of such records with the laboratory data would enable the life of the conductor under the actual wind conditions to be estimated fairly accurately. How this was done, and the results obtained, are thoroughly covered in a paper presented at the 1948

CIGRE meeting in Paris.[4] However, a word about the results will be pertinent to the later discussion herein.

It was found that, based on the manner in which the cable was vibrating in the wind over a 2-year period, the life of the conductor should be well over 50 years, with an ample safety factor. Amplitudes were such as to produce cable bending in very small amounts. Figures 1 and 2 indicate the extent to which the results of these tests justified the conclusion. The top curve of each figure shows the relationship between the number of cycles required to produce failure in the laboratory and the corresponding amount of bending. The lower curves represent the number of cycles of vibration which can be expected, during an extrapolated 50-year period, to produce the indicated amounts of bending. The latter curves all lie well below the vibration intensity life curve established by the long sample life tests. The distance between the top curve and those below was great enough to provide a comfortable factor of safety against the vagaries of wind and the admittedly dubious risk of extrapolating the weather of 2 years to 50 years. Vibration dampers were not felt to be actually needed in view of these comparisons.

However, during the course of the vibration investigations a Department engineer, F. L. Goss, invented a low-cost torsional damper which proved to be effective in limiting vibration amplitudes on the Hedernheim conductor. These dampers were applied in locations which were regarded as particularly bad from a vibration standpoint, not over 10 per cent of the line being thus equipped initially. The patrolmen were instructed to report on any locations where vibration was noticeable, and through the years additional dampers have been added one by one, though some 85 per cent of the lines has never been protected by hese dampers.

OPERATING EXPERIENCES WITH CONDUCTOR VIBRATION

THE INITIAL two circuits of the 287.5-kv Boulder transmission lines of the Department were constructed 15 years ago, and the third circuit has been in service for 10 years. During the last few years increasing numbers of reports have been coming in from the patrolmen that certain sections of the lines appear to be vibrating more. No particular significance was attached to these reports, because the men had been instructed to report on vibration which they observed.

On November 4, 1949, patrolmen found the first segment breaks in the Hedernheim-type copper conductors of the line, on the most recent circuit to be erected. They were located between the torsional damper and a suspension clamp, being 14 inches from the damper. Examination of the cable, on removal, showed the marks of a come-along near the break. It was concluded that the wire had been damaged in erection, and that the damage had

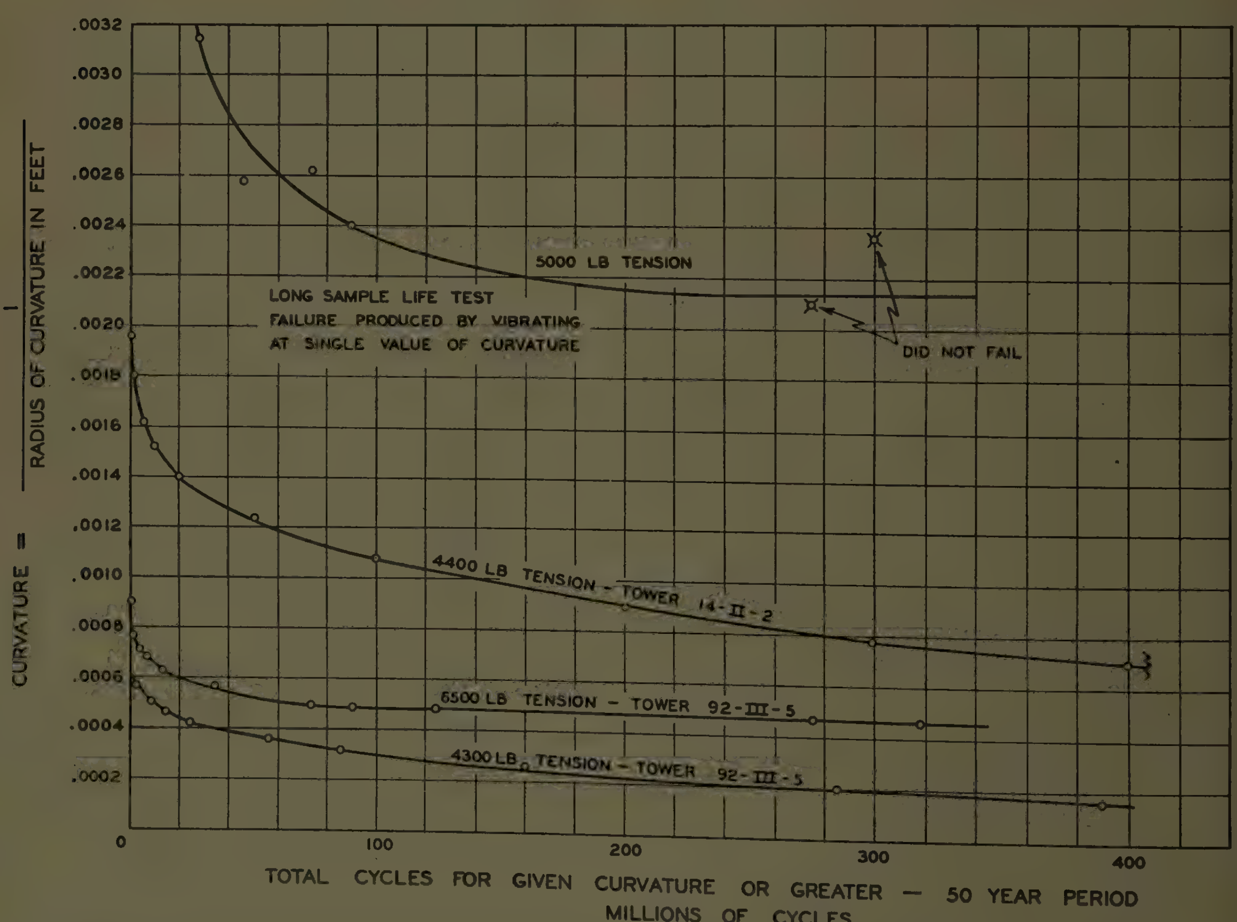
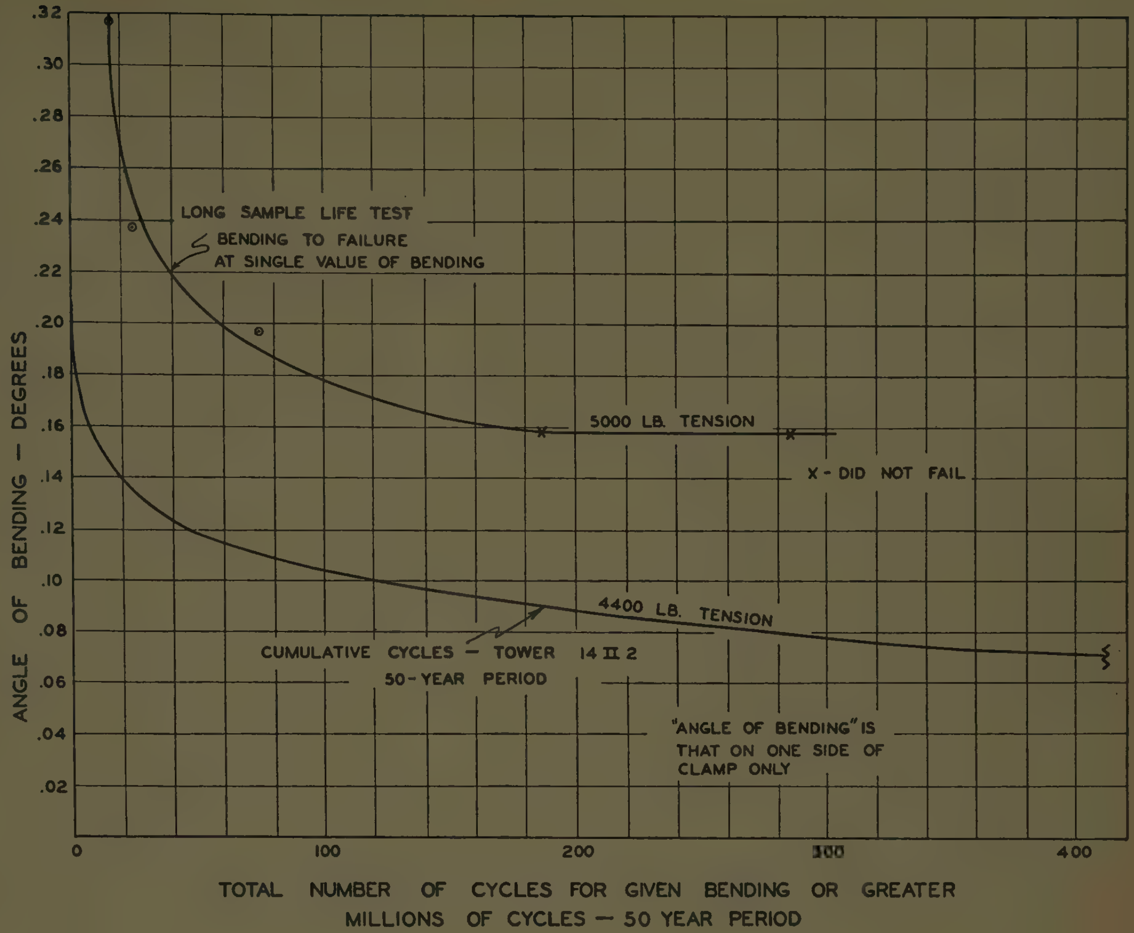


Figure 1. Comparison between cycles of bending in the span required to produce failure and cycles of bending in the span experienced in the field, extrapolated to cover a 50-year period

ure 2. Compari- between cycles of ding between le and clamp uired to produce ure and cycles of ding between le and clamp erienced in the d, extrapolated to er a 50-year period



ortened the life of the cable at that point. Attention as focused on the cable by the occurrence, and on No- mber 6 another break was found, this time on one of the iginal circuits. The damage was out 50 feet from a uble-circuit tower, and here again the trouble was aced to the fact that this particular span had been one at had dropped when an adjacent tower washed out in e flood of 1938. The cable was obviously scarred around the break, and it was fairly certain that one of these scars had contributed to the early segment failure. These two cases of broken segments served further to make the patrolmen conscious of the conductor, and on December 5 the third case of cracked segments was found, this time at the edge of the wedge in the free-center suspension clamp.

ble II. Segment Failures from Vibration on Boulder Transmission Line Hedernheim-Type Conductor

Tower Location Miles from oover Dam)	Goss Vibration Dampers	Location of Broken Segments	Remarks
188	Yes	Between damper and clamp 14 inches from damper	Result of come-along kink in cable inhibiting segment movement
226	No	50 feet east of tower	Result of bad scar on section of cable dropped on rocks when erected after tower washout in 1938 flood
253	No	At edge of wedge in free-center clamp	
262	Yes	Between damper and clamp within 5 inches of damper	
131	No	Top side of conductor over and just inside saddle of clamp	
148	No	Top side of conductor over and just inside saddle of clamp	
92	No	Between free-center clamp and west saddle	
91	No	1-inch west of free-center clamp	
87	Yes	2-inches east of suspension clamp	

A detailed examination of the entire transmission line was undertaken following this development, and a total of nine points at which segment cracks had occurred was found after complete tower-by-tower and span-by-span inspection. The cases of trouble are shown in Table II.

Measurements of vibration amplitudes at selected spots on the energized lines soon showed that vibration was being experienced far in excess of any ever measured in the initial two years of investigation. It was clear that some form of vibration inhibitor would be required, and a 180-foot section of conductor was cut out of the line near one of the towers where a segment break had occurred and was shipped to the Ryan Laboratory at Stanford University for tests to determine the best design for a damper to cope with the new conditions.

Methods used by Dr. J. S. Carroll, director of the Ryan High Voltage Laboratory, for vibrating a test length of conductor and measuring the energy required to sustain vibration have already been reported.[5] The Hedernheim-type conductor had been subjected to this type of measurement previously, and the energy required to vibrate the cable both with and without the Goss torsional damper had been measured and recorded. It was astonishing to find that the sample of cable, removed from the line after

15 years of service, required very much less energy to vibrate it than was required when it was new. Further, the torsional dampers were far less effective in controlling the vibration amplitudes than they were in the initial measurements with new cable.

This development gave rise to three schools of thought on the subject of vibration and the possible causes for

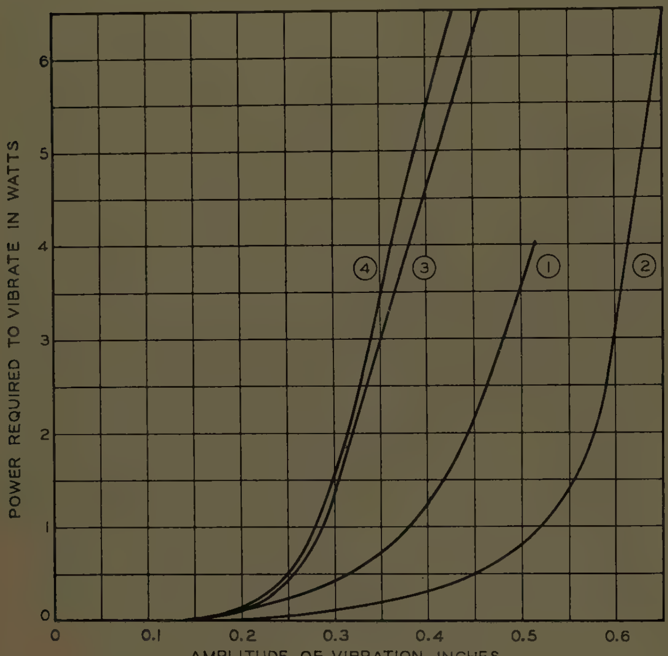


Figure 3. Vibration tests on 1.4-inch Hedernheim-type cable. Tension, 5,000 pounds; frequency, 11.6 cycles per second; cable length, 167 feet; number of loops, 12; no vibration dampers

1. Cable when new (1936 test). 2. Old cable (taken down after 15 years' line service) before brushing oil on cable. 3. Old cable 12 hours after being brushed with oil. 4. Old cable washed with cleaning solvent 3 days after oiling

increased vibration tendencies with age. One group of engineers was of the opinion that the friction between segments had lessened through the years, and that this lessened friction allowed the composite cable to vibrate more easily. Another group pointed out that the copper might have become changed in structure after 15 years of vibration. A third group of engineers, which included the top design men of the manufacturer of the cable, on being informed of the test results, analyzed the possible cause as increased friction between the segments, permitting the cable to vibrate more nearly like a tube.

In an effort to determine the true cause for the change in vibration characteristics, a test was devised which could serve to rule out at least one of the three possibilities advanced. This test consisted in taking a set of energy measurements required to vibrate the conductor as found, and then to brush the entire length of the cable with a light dynamo oil, leave the test setup intact overnight, and then repeat the energy measurements the following day.

This was done, and the energy measurements made on the following morning showed that the lubrication had greatly increased the amount of energy required to vibrate the cable, actually increasing it over that required when new. Figure 3 gives the results of these tests.

As further corroboration, on fastening the torsional dampers in place for a second test run on the oiled conductor, it was found that they were again as effective as they had once been when the cable was new.

It was thus clearly indicated that the cause of increased vibration tendencies, and the probable cause of breaks, was the fact that segment friction had increased in the 15 years of line operation, and this lack of ability for the segments to slip and absorb energy was reducing the amount of energy that could be absorbed by the cable with a given amount of bending. Reduction of the amount of energy that could thus be absorbed meant that a given wind could produce larger amplitudes of vibration in the conductor.

The effectiveness of the oil was indicated when efforts were made to wash it out of the segments with a cleaning solvent. Only a very small change was noted, and this change was toward the higher energy range.

Experiments with types of vibration dampers other than torsional, which lose effectiveness with critical increases in friction between segments, have shown that the increased vibration amplitudes observed in many locations on the Boulder lines can be controlled readily. Dampers of either the Stockbridge or of the Swedish type are highly effective in limiting amplitudes to low safe values. Certainly some type of effective vibration damper is needed, if only to provide a margin of safety against the universal phenomenon of conductor vibration. Through the use of lower tensions and meticulous clamp design, an economical line was built which provided initially such excellent vibration characteristics that total application of dampers was unnecessary. And this condition would probably have prevailed for the life of the line had the vibration characteristics remained the same. The fact that this phenomenon was not anticipated may have slightly delayed the application of appropriate dampers. In any event it is believed that the installation of dampers as now proposed will, even with the change of conductor characteristics, operate to maintain the original safety margin indicated in Figures 1 and 2.

No vibration troubles of any kind have ever been experienced on the 1/2-inch extra-high-strength steel strand used as ground wires on nearly all Department lines, and to date no vibration dampers have ever been installed.

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High-Speed Relays in Electric Analogue Computers

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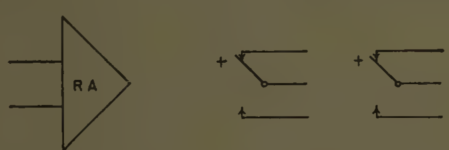
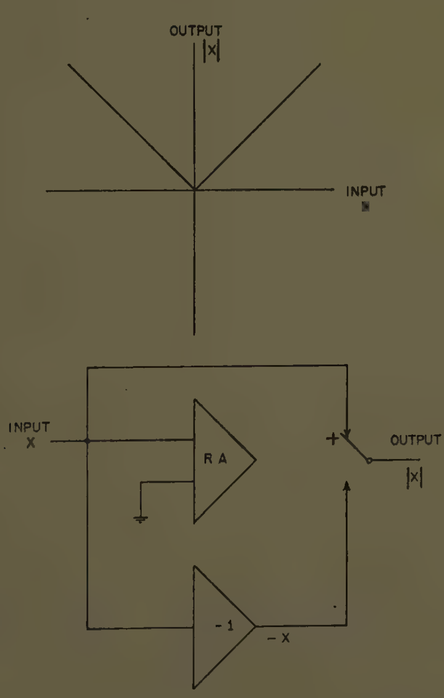
ANALOGUE COMPUTERS usually are considered to perform combinations of seven basic mathematical erations: addition, subtraction, multiplication, division, ferentiation, integration, and function generation. This ticle considers applications of a comparison operation ich consists of a comparison of two quantities followed one or more of the seven basic operations.

Comparison operations, or operations involving logical oice, are familiar to digital computers. By addition the comparison operation to the repertoire of an analogue mputer the latter may be made to perform digital mputations. In a sense, an analogue computer so uipped is a more general instrument than its digital other. It is capable of manipulating either continuous discrete quantities.

A high-speed relay, driven by a high-gain d-c amplifier, ay be used to effect comparison operations in an electric alogue computer. Such a combination, here termed a lay amplifier, has been constructed to operate in less an 1 millisecond with an operating sensitivity (limited drift, hum, and noise) of a few millivolts. The relay nplifiers are polarity sensitive in that only one polarity input voltage will operate the relay. The relay amplifier

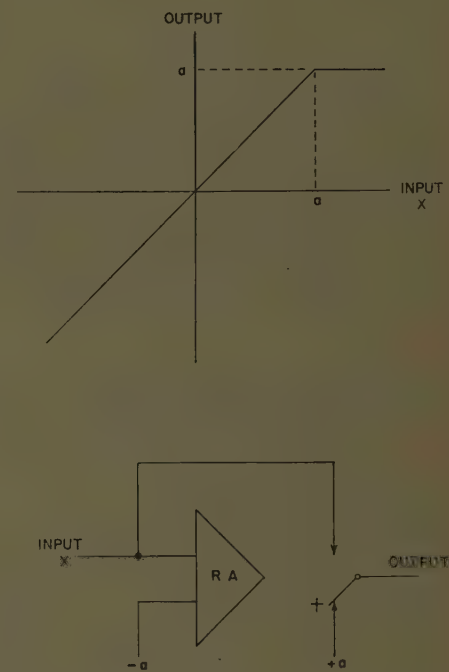


gure 1. Symbol for a relay amplifier. Relay contacts connected as shown when the sum of the inputs is positive



igure 2. Circuit r generating the osolute value of an input

Figure 3. Circuit for simulating a limit stop



then makes a comparison of its input (or sum of inputs) and zero. The relay contacts effect the subsequent computing operations.

The symbol used here for a relay amplifier is shown in Figure 1. The relay armatures are in the position shown when the sum of the amplifier inputs is positive. The armatures switch to the opposite terminals when the sum of the amplifier inputs is negative.

Figure 2 shows a relay amplifier and inverting amplifier (an amplifier having a negative gain of unity) connected to form an output which is equal to the absolute value of the input, as shown graphically. The relay selects the input if it is positive, or the negative of the input if the input is negative. Generation of the absolute value is of course synonymous with full-wave rectification.

In Figure 3 is shown an arrangement for limiting a variable. The output is equal to the input unless the value of the input exceeds a, in which case the output is kept at a by the relay. It is not necessary that a be a constant; if x and a are both variables this circuit selects the smaller of the two.

The techniques illustrated may be extended to simulate any characteristic, single, or multivalued, which can be represented graphically by a combination of straight line segments. The methods of symbolic logic may be applied in systematizing the synthesis of such circuits.

Digest of paper 51-291, "The Use of High Speed Relays in Electric Analog Computers," recommended by the AIEE Committee on Computing Devices and approved by the AIEE Technical Program Committee for presentation at the AIEE Pacific General Meeting, Portland, Oreg., August 20–23, 1951. Scheduled for publication in AIEE *Transactions*, volume 70, 1951.

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A Static Magnetic Exciter for Synchronous Alternators

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By designing the basic exciter circuit of an alternator to make the machine as self-regulating as possible, and using the remaining deviations of output voltage to provide a correction signal to the exciter, the steady-state alternator voltage can easily be kept within ±0.6 per cent. No antihunt means are needed, transient response is rapid, and a short circuit will not cause loss of excitation.

ONE OF THE fundamental functions of a voltage regulator is to keep the terminal voltage of the alternator constant at various loads. To achieve this end, the excitation of the alternator must be adapted to the alternator line current in magnitude and phase. It has been shown[1] that the line-to-neutral voltage drop $\Delta \boldsymbol{E}$ equals

$$\Delta \boldsymbol{E} = -jX_s\boldsymbol{I} \tag{1}$$

where X_s is the synchronous reactance of the alternator and $\boldsymbol{I}$ is the line current. Equation 1 assumes a cylindrical rotor, no saturation, and no resistance of the armature winding. It is interesting to note that a typical alternator has a voltage drop $\Delta \boldsymbol{E}$ in the vicinity of rated terminal voltage when loaded with rated line current at zero power factor. This is a very large voltage drop by comparison with a d-c generator which has a typical regulation of only 4 per cent of rated terminal voltage. It follows that the excitation of an alternator has to cover a relatively wide range. As a result, alternators usually require high-gain regulators which often pose stability problems. The excitation system described, however, avoids the need of a high-gain regulator by attempting inherent compensation for the voltage drop $\Delta \boldsymbol{E}$. To compensate for the voltage drop $\Delta \boldsymbol{E}$, the excitation is required to provide an inner (fictitious) voltage $\boldsymbol{E}_i$

$$\boldsymbol{E}_i = \boldsymbol{E}_t + jX_s\boldsymbol{I} \tag{2}$$

as shown in Figure 1. This inner voltage $\boldsymbol{E}_i$ is proportional to the field (excitation) ampere turns I_fN_f

$$\boldsymbol{E}_i = k(I_fN_f) \tag{3}$$

where I_f is the field current of the alternator, N_f the number of field turns per pole, and k is a factor involving a number of machine constants, such as number of turns in the a-c winding, size of air gap, and so forth.

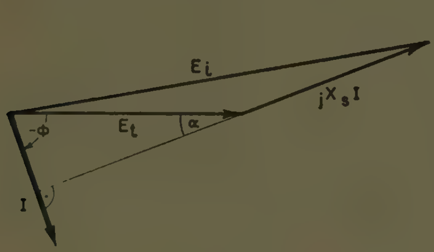

Figure 1. Voltage vector diagram of an idealized alternator with cylindrical rotor

When saturation is present, or for an a-c winding whose resistance is not negligibly small, or when the alternator is of the salient-pole type, deviations from equation 2 will occur. To correct for these deviations, means are provided which are discussed later in the text. Nevertheless, equation 2 remains of fundamental importance for the compensation of the alternator voltage drop $\Delta \boldsymbol{E}$.

VOLTAGE-DROP COMPENSATION

VOLTAGE-DROP compensation is obtained by a field current I_f which is proportional to the magnitude of $\boldsymbol{E}_i$, which in turn is determined by the terminal voltage $\boldsymbol{E}_t$ and the alternator alternating current $\boldsymbol{I}$ as shown in Figure 1.

In Figure 2 is shown a 3-phase alternator, connected through three identical current transformers CT to the load. There are also three identical, linear reactors X_1 which are interconnected with the secondaries of the current transformers to three identical resistors R. These resistors symbolize the resistance of the alternator field and it will be shown that the current through the resistors R is proportional to $\boldsymbol{E}_i$.

Assuming a symmetrical 3-phase load, points 7 and 8 of Figure 2 will be at the same potential as the neutral 0 of the alternator. By connecting 7 and 8 to the neutral 0, no changes in the system currents will occur; the system, however, degenerates into three single-phase systems, Figure 3, which are simpler to analyze.

The current transformer CT of Figure 3 is shown by its equivalent circuit in Figure 4 when winding resistances and leakage reactances are neglected.[2] Resistor R is the same as shown in Figure 3 and X_2 is the magnetizing reactance of the secondary of the current transformer CT. Denoting the turn ratio of primary to secondary turns

$$N_p/N_s = a \tag{4}$$

the alternator current $\boldsymbol{I}$ when referred to the secondary of the current transformer becomes $\boldsymbol{I}'$

$$\boldsymbol{I}' = a\boldsymbol{I} \tag{5}$$

Essentially full text of paper **51-196**, "Static Magnetic Exciter for Synchronous Alternators," recommended by the AIEE Committee on Power Generation and approved by the AIEE Technical Program Committee for presentation at the AIEE Summer General Meeting, Toronto, Ontario, Canada, June 25–29, 1951. Scheduled for publication in AIEE *Transactions*, volume 70, 1951.

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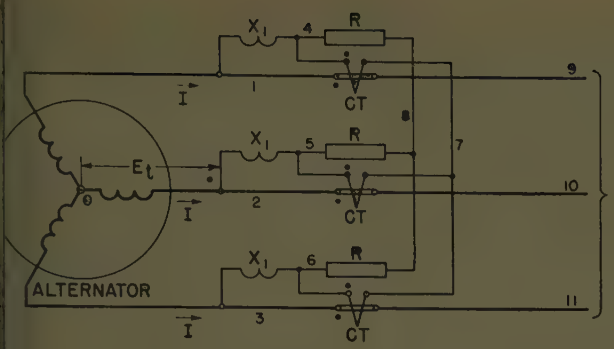
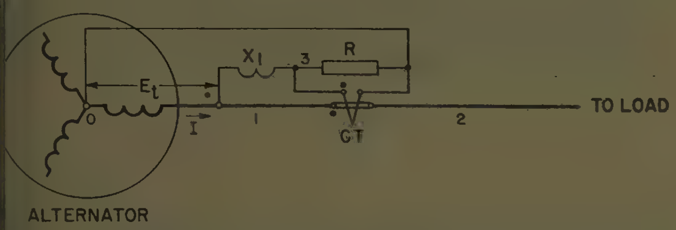


igure 2. **Three-phase network to reconstruct the internal alternator voltage E_i**



igure 3. **Single-phase portion of the 3-phase network of Figure 2**

The equivalent circuit of Figure 3 is now shown in Figure . The quantity to be determined is the current I_R which ill appear finally to be proportional to the field current I_f. Acting in the circuit are the terminal voltage E_t and the eferred alternator current aI. Accordingly, the current $_R$ can be seen to consist of two components of which $I_{R,E}$ is erived solely from E_t, and $I_{R,I}$ is derived solely from I

$$_R=I_{R,E}+I_{R,I} \tag{6}$$

Determination of $I_{R,E}$. Assume $I=0$ and apply Thévenin's heorem:[3] with R disconnected, the terminal voltage $E_{2\text{-}0}$ etween 2 and 0 is

$$E_{2\text{-}0}=E_t\frac{X_2}{X_1+X_2} \tag{7}$$

The source impedance X, as seen from the terminals 2-0, s equal to X_1 and X_2 in parallel

$$X=\frac{X_1X_2}{X_1+X_2} \tag{8}$$

The current $I_{R,E}$ becomes

$$I_{R,E}=\frac{E_{2\text{-}0}}{R\left(1-j\frac{X}{R}\right)} \tag{9}$$

nd substituting from equation 7

$$I_{R,E}=E_t\frac{X_2}{X_1+X_2}\frac{1}{\sqrt{R^2+X^2}}\underline{/\theta_1} \tag{10}$$

$$\theta_1=-\arctan X/R \tag{11}$$

The angle θ_1 is the angle from E_t to $I_{R,E}$ (Figure 6).

Determination of $I_{R,I}$. Next, assume $E_t=0$

$$I_{R,I}=aI\frac{1/R}{(1/R)+(1/jX)}=aI\frac{1}{1-j\frac{R}{X}} \tag{12}$$

nd

$$I_{R,I}=aI\frac{X}{\sqrt{R^2+X^2}}\underline{/\theta_2} \tag{13}$$

$$\theta_2=\arctan R/X \tag{14}$$

The angle θ_2 is from I to $I_{R,I}$.

It follows from equations 11 and 14

$$\theta_2=\theta_1+\frac{\pi}{2} \tag{15}$$

If the current I is lagging the terminal voltage E_t by an angle ϕ (Figure 1), the angle between iX_sI and E_t equals

$$\alpha=\frac{\pi}{2}-\phi \tag{16}$$

Let us now determine the corresponding angle β between $I_{R,I}$ and $I_{R,E}$. If the line current I lags ϕ radians behind E_t, $I_{R,I}$ lags behind E_t by the angle θ_2'

$$\theta_2'=\theta_2-\phi=\phi_1+\frac{\pi}{2}-\phi \tag{17}$$

The angle β between $I_{R,I}$ and $I_{R,E}$ (Figure 6) becomes

$$\beta=\theta_2'-\theta_1=\frac{\pi}{2}-\phi \tag{18}$$

This proves that

$$\alpha=\beta \tag{19}$$

which is a necessary condition for the similarity of the triangles OAB and OCD (Figure 6).

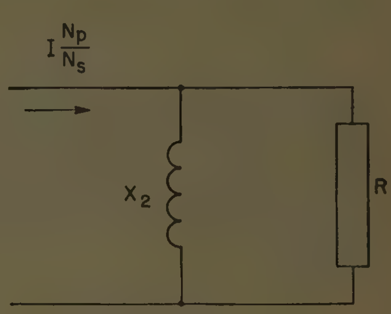


Figure 4. Equivalent circuit for idealized current transformer CT of Figure 3

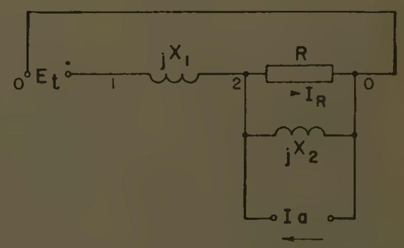


Figure 5. Equivalent circuit for the single-phase network of Figure 3

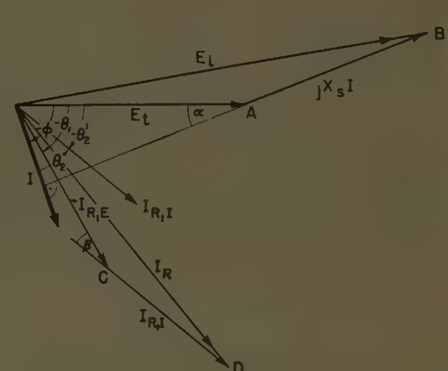


Figure 6. Vector diagram of currents obtained from the single-phase circuit

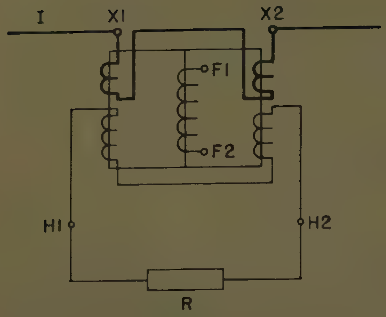


Figure 7 (left). Schematic of a saturable current transformer

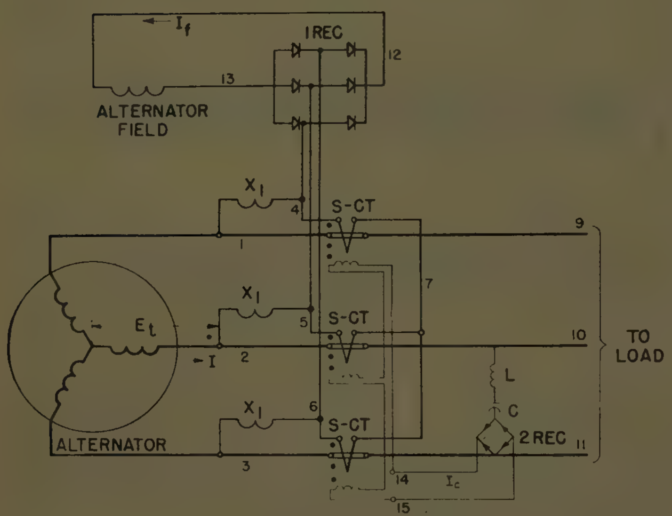


Figure 8. Circuit of static exciter, including correction circuit

By proper selection of X_1, X_2, and a, the ratio of $\boldsymbol{I}_{R,I}/\boldsymbol{I}_{R,E}$ can be made identical to the ratio $X_s\boldsymbol{I}/\boldsymbol{E}_t$; hence the vector diagram *OAB* becomes similar to *OCD*. The resultant current $\boldsymbol{I}_R$, equation 6, will therefore be proportional to the required excitation at any terminal voltage and at any load. By rectifying the current I_R, the alternator field current I_f is obtained.

CORRECTION CIRCUIT

THE FIELD current I_f will compensate for most of the inherent alternator voltage drop, equation 1, but does not produce a perfect compensation for the drop, because an actual alternator deviates to some extent from the assumptions previously made; furthermore, the alternator field resistance is subject to variation due to temperature changes, which also will affect the alternator terminal voltage. To obtain the desirable high degree of alternator voltage constancy, a correction consisting of a voltage-sensitive circuit is superposed on the excitation system.[4] This correction circuit modifies the magnitude of the current $\boldsymbol{I}_R$ and, hence, the field current I_f. Because the excitation system (without correction) makes the alternator nearly self-regulating, only a small amount of gain is now necessary for the superposed correction circuit. As a result of this low gain, antihunt means are not necessary.

The magnitude of $\boldsymbol{I}_R$ is determined trigonometrically from equations 6, 10, and 13.

$$I_R^2 = \frac{X_2^2}{R^2(X_1+X_2)^2+X_1^2X_2^2}(E_t^2+a^2I^2X_1^2-2E_taIX_1\sin\phi) \qquad (20)$$

It will be observed that $\boldsymbol{I}_R$ varies with X_2. By applying d-c ampere turns to the current transformer *CT* of Figures 2 and 3, saturation can be effected in the cores, resulting in a change of X_2 and subsequently a change of $\boldsymbol{I}_R$.

A schematic diagram of such a transformer, called a saturable current transformer and designated by *S-CT*, is shown in Figure 7. A 3-legged core structure is used. The primary a-c windings are between terminals X_1, X_2, and the secondary a-c windings are between terminals H_1, H_2. The d-c control winding with its terminals F_1, F_2 is wound around the center leg. Because of the polarities of the windings, the a-c fluxes of fundamental frequency and higher, odd harmonics circulate between the outer legs, and no voltage of fundamental or odd frequency is induced in the control winding.[5] A group of three such saturable current transformers is shown in Figure 8.

The excitation circuit, including the saturable current transformers, is shown in Figure 8. Instead of having points 4, 5, and 6 connected to the resistors *R* (Figure 2), they are now connected to a 3-phase bridge rectifier 1*REC* which energizes the field of the alternator. The control windings of the saturable current transformers are connected in series and terminate at 14 and 15.

To superpose corrective action on the excitation system, the control windings of the saturable current transformers are energized from a nonlinear resonant circuit.[6] The single-phase voltage for the energization of this circuit may be taken directly from one phase of the alternator, or it may be obtained from a circuit which produces the average voltage of the three phases of the alternator.

The nonlinear circuit consists essentially of a capacitor *C*, an iron-core reactor *L*, and a rectifier 2*REC* which energizes the control windings of the saturable current transformers.

Figure 9. Current I_c of correction circuit as a function of alternator terminal voltage E

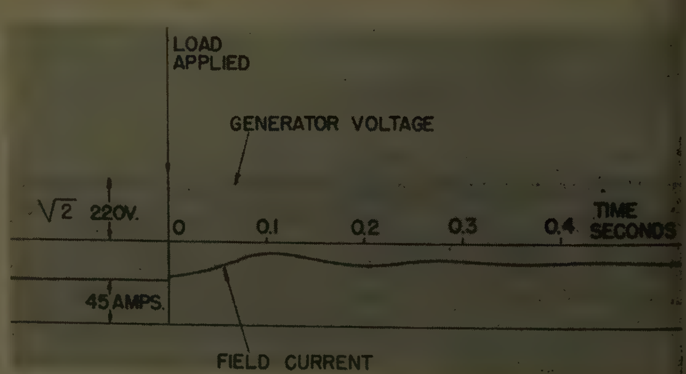


Figure 10. Alternator is suddenly loaded with one-half of rated current at a power factor of 0.4 inductive

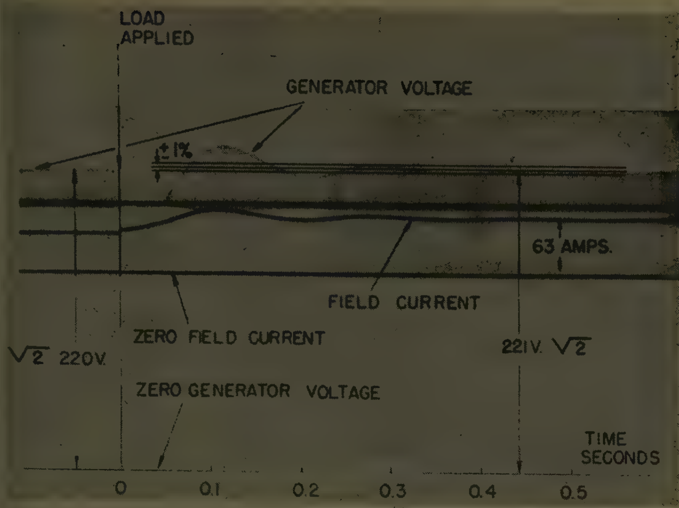


Figure 11. Same loading as in Figure 10. Oscillogram is taken with suppressed zero line to amplify details

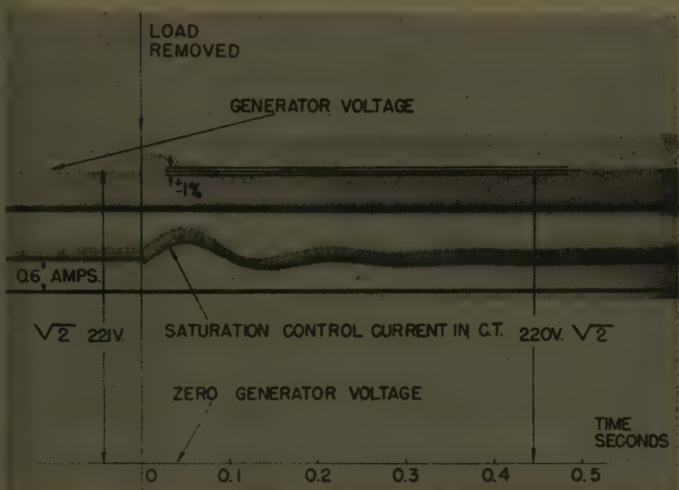


Figure 12. Alternator suddenly loses its load, which consisted of one-half of rated current at a power factor of 0.4 inductive

The current flowing in this nonlinear circuit is shown in Figure 9 as a function of the applied voltage. In the vicinity of *A*, which is the operating region, a small change in the alternator voltage $\boldsymbol{E}$ causes a very large variation in the current I_c. If, for instance, the alternator voltage $\boldsymbol{E}$ increases, the current I_c in the nonlinear circuit rises sharply. This produces additional saturation in the saturable current transformers, resulting in a reduction of X_2, and hence in the desired reduction of field current I_f, equation 20. In cases where the power output of this nonlinear circuit is not sufficient for its direct application to the saturable current transformers, a suitable magnetic amplifier may be interposed for this purpose.

PERFORMANCE

The described static exciter has been tested on a salient-pole alternator of the following description: 3-phase; frequency, 420 cycles per second; line-to-line voltage, 220 volts; rated current, 730 amperes; power factor, 0.8 inductive; synchronous reactance, 0.89 per unit; leakage reactance, 0.22 per unit; open circuit field time constant, 0.25 second; field current for rated alternator current, 80 amperes; field resistance at 25 degrees centigrade, 0.805 ohm, at 90 degrees centigrade, 1.03 ohms; air gap, 0.091 inch; speed 1,800 rpm.

Significant for the performance of a voltage regulator are: steady-state regulation accuracy; transient response; and alternator current during short circuits.

Steady-State Regulation Accuracy. The voltage drop of the alternator is shown in Table I.

Transient Response. The transient response of the system is demonstrated by the oscillograms shown in Figures 10 to 13. Figure 10 shows the generator voltage and the field current when the alternator is suddenly called on to provide half its rated load current at a power factor of 0.4 inductive. To observe more accurately the alternator voltage, the same transient was repeated by using a suppressed zero line[7] for the alternator voltage (Figure 11). It will be seen that on application of the load the alternator voltage rapidly recovers and then approaches its sustained value in a highly damped manner. For instance, only 310 milliseconds after the inception of the load, the alternator voltage is already within ±1 per cent of the final sustained value. Figure 12 shows the case where the previous load was suddenly removed. Here, the recovery to within ±1 per cent occurs after only 130 milliseconds.

Short Circuit. Another feature of this exciter system consists in its ability to maintain excitation under short-circuit conditions. This feature is important for the selective tripping of protecting devices. An oscillogram of a short-circuit test is shown in Figure 13; it will be observed that the

Table I. Steady-State Regulation Accuracy

Type of Load	Alternator Load Current Referred to Rated Current, Per Unit	Power Factor Inductive, Per Unit	Voltage Drop, Per Cent
Three-phase	1.0	0.75	0.2
Three-phase	1.0	0.06	1.2
Three-phase	0.5	0.4	0.5
Single-phase	0.15	0.96	−0.13

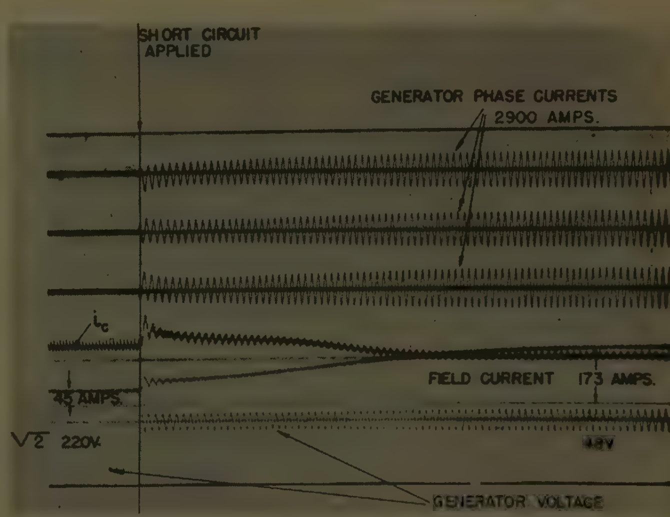


Figure 13. Oscillogram of short-circuit test

Figure 14. A-c components of the excitation system showing power supply transformer (top), three linear reactors X_1 below, and at the bottom three saturable current transformers S-CT

alternator current increases to almost four times its rated value.

At the point of measurement, the alternator voltage did not quite reach zero because of the impedance in the cables to the short-circuiting circuit breaker. This residual alternator voltage, however, is only coincidental and has no bearing on the basic performance of the system.

The a-c components of the excitation system are shown in Figure 14.

NOMENCLATURE

a = turn ratio
E_i = inner (fictitious) line-to-neutral voltage of the alternator, volts
E_t = line-to-neutral terminal voltage of the alternator, volts
ΔE = line-to-neutral terminal voltage drop of the alternator, volts
I = alternator load current, amperes
I_c = current in correction circuit, average amperes
I_f = alternator field current, amperes
I' = alternator load current, referred to secondary of current transformer, amperes
I_R = current in resistor R, amperes
$i = \sqrt{-1}$
N_1, N_2 = number of turns of primary and secondary, respectively, of current transformer
N_f = number of turns per pole of alternator field
R = resistance in a-c exciter circuit, representing resistance of alternator field, ohms
X_1 = reactance of linear reactors, ohms
X_2 = secondary magnetizing reactance of current transformers, ohms
X = reactance of X_1 and X_2 in parallel, ohms
X_s = synchronous reactance of alternator, ohms
ϕ = phase angle between E_t and I, radians

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An Improved Polar Telegraph Relay

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A new attack on the relay design problem has led to improved long-term dependability, maintenance-free life, and reduction in size and cost. A novel armature and contact mounting design provides better transmission performance than that of any other relay now in large-scale use.

POLAR RELAYS have been used since the early days of telegraphy for the direct reception of line signals and also as repeating devices for feeding other lines or equipment. They have been subject to periodic improvement in design and performance. Generally speaking, the widely used polar relays some years ago attained transmission efficiencies which left little to be desired. However, further attack on the relay design problem toward the goal of improvement in dependability, increase of maintenance-free life, and substantial reduction in size and cost have led to the development of a new polar relay which promises to have important applications.

Even though tremendous advances have been made in the development of electronic devices, the relay continues to play an important role in the operation of modern

Full text of paper 51-238, "An Improved Polar Telegraph Relay," recommended by the AIEE Committee on Telegraph Systems and approved by the AIEE Technical Program Committee for presentation at the AIEE Fall General Meeting, Cleveland, Ohio, October 22–26, 1951. Not scheduled for publication in AIEE *Transactions*.

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elegraph systems. The relay can perform many functions etter and more economically than the electron tube. In act, some functions are difficult to perform electronically, articularly where isolation between circuits is required. Hence, the use of relays is increasing not only in the elegraph company but also in many other organizations.

Polar relays are more sensitive than neutral relays sometimes called single-current relays) and are fundamentally different in operation in that the movement of he armature depends upon the direction of the operating current. In the polar relay two magnetic paths for the magnetic fluxes must be provided: one for the flux produced by a permanent magnet and the other for the flux produced by the operating current. These paths usually are not entirely separate, in that some portions of the magnetic circuit are common to both paths. The path for the flux from the permanent magnet is arranged in the form of a bridge or a similar balanced configuration with respect to the armature so that a center position of the armature exists at which the forces due to the permanent magnet flux in two sides of the bridge cancel. A slight movement of the armature from this center position results in the magnetic forces being unbalanced, the resulting force on the armature acting in the same direction that he armature is moved from the center position. This motion is limited by contacts disposed on opposite sides of he center position, and ordinarily the armature will rest on either contact to which it is moved. The force with which the armature rests upon the contacts is called banking and is usually measured by the amount of energization in he operating winding required to move the armature from one position to the other.

The path for the flux produced by the operating current s disposed in the bridge in such a manner that the magnetic forces on the armature are unbalanced when operating flux exists. An operating current in one direction unbalances he forces in the bridge in one direction, and current in the opposite direction unbalances the forces in the opposite direction, so that the armature movement depends upon he direction of the operating current. This action of the operating current in unbalancing a magnetic bridge in which the permanent magnet flux is many times larger han the operating flux results in the polar relay being more sensitive than the neutral relay. The magnitude of the pull acting on the armature is approximately proportional to the product of the polarizing flux and the flux generated by the operating current in a polar relay and to the square of the operating flux in a neutral relay, which shows why a high polarizing intensity is effective n producing a highly sensitive polar relay as compared to neutral relay. However, a practical limit exists in the polarizing intensity that can be employed since magnetic saturation of any part of the operating flux path will reduce the effectiveness of the operating current in generating flux.

MAGNETIC CIRCUITS

In Figure 1 (A)-(H) are shown schematic diagrams of the magnetic circuits of a number of different types of relays. The permanent magnet and its flux paths are shown in heavy outline and the operating magnetic sections and flux paths in light outline. These diagrams are intended to show only the arrangement of the magnetic circuits and not the relative dimensions or arrangement of the mechanical parts.

Figure 1(A) is representative of the early European relays such as the Siemens. The magnetic circuit of the Wheatstone relay which was used extensively in telegraphy for many years is shown in Figure 1(B). Actually the two armatures are carried on a pivoted spindle which also carries the relay tongue. This relay was replaced in practically all Western Union services by the *17*-type, which has remained the standard of reliable and rugged performance for many years. The magnetic circuit of the *17*-type shown in Figure 1(C) is only slightly different from the circuit of Figure 1(A), but due to a superior arrangement of magnetic parts, materials, and so forth, produces a relay of superior performance. In Figure 1(D) is shown a type of magnetic circuit which has been used extensively in the United States and abroad. An example is the British Carpenter relay. Modifications of Figure 1(D) as shown in Figure 1(E) and (F) have been used extensively, particularly in the United States. The Western Electric *215*, using a spring-mounted armature, and the Western Union *31*-type, having a pivot-mounted armature, are examples of relays using the circuit of Figure 1(F). It will be noticed that in all of these circuits the path of the flux generated by the operating current does not include the permanent magnet which has high reluctance and is not a suitable material for carrying the flux generated by the operating current. Each of these magnetic circuits has

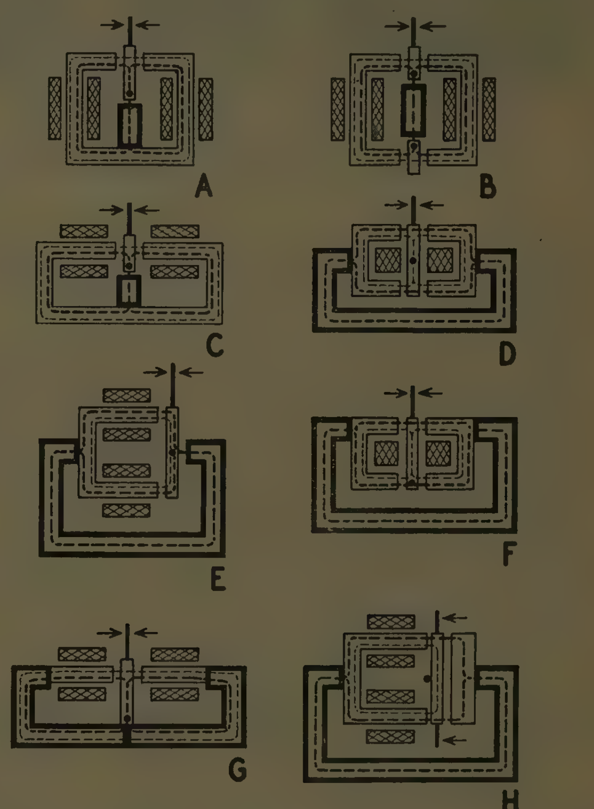

Figure 1. Some typical magnetic circuits as used in polar relays

some advantages and disadvantages, but all are suitable for use in efficient polar relays. An example of an inefficient circuit is shown in Figure 1(G) in which the path of the operating flux includes the permanent magnet. Typical relays which have been used extensively in telegraph practice are shown in Figure 2. These are the early Wheatstone, the Western Electric *215*, and the Western Union *17*-type.

Figure 2. Typical polar relays in common use

Relays have been the subject of periodic, if not continuous, development effort to produce a cheaper, better, and more compact instrument. The result of a recent design effort, which sought to produce an inexpensive relay with a long period of maintenance-free life, is a relay of greatly improved characteristics.

In Figure 3 are shown two prototype models of this relay, which has been coded type *202-A*, and a book of matches for comparison of size. The small size and simplicity of construction are of increasing importance in the design of the modern telegraph relay. These considerations result in the use of a minimum number of parts and the elimination of all unnecessary adjustments, particularly those for use while the relay is in service. A base with provision for 11 connections has been standardized for these relays.

CONSTRUCTION OF THE 202-TYPE RELAY

THE MAGNETIC circuit used in this relay is shown in Figure 1(H). The major components are shown in Figure 4. The mounting is a single plastic molding which carries most of the relay components on the front and a permanent magnet in a depression on the back. The operating magnetic circuit is simply eight U-shaped laminations, 0.014 inch thick, with outside dimensions $1^1/_8$ by $1^3/_8$ inches, driving a bar armature 1/8 inch square by $1^1/_8$ inches long, which carries a standard tungsten carbide contact at each end. The mating tungsten carbide contacts are supported by a rigid spring so that the contact spacing can be varied without rotation of the movable contact, thus preserving the same surface alignment for all contact spacing adjustments. High magnetic efficiency is obtained by a tightly closed path to the armature for the flux produced by the operating current. The permanent magnet is held in position by its own attractive pull to the center of the U-shaped laminations and the pole shoe used to distribute the polarizing flux through the relay structure. The path of the polarizing flux, Figure 1(H), is such as to exclude most of the length of the armature, thus leaving the armature free to carry mostly flux produced by the operating current. Because of the increased magnetic efficiency, the coils occupy smaller space and require fewer turns for normal operating conditions than in previous relays. The coils are suitable for winding by modern mass production methods, and are merely slipped over the ends of the laminations in much the same manner as in an inexpensive commercial transformer.

Two methods of supporting the armature have been developed as shown by the two models in Figure 3. In the relay to the right the armature is held in position in two degrees of freedom by magnetic forces supplied by the permanent magnet; that is, the armature maintains its endwise and vertical positions by maintaining a balance in the permanent magnet field between the pole shoe and the ends of the laminations. The restraining force to the third degree of freedom is a tungsten carbide post, set in the molding, about which the armature rocks while in operation. Since the air gaps between the laminations and armature are small as compared to the air gap between the pole shoe and armature, the armature is held with considerable force upon the post. A thin flat tungsten carbide plate is fastened to the armature at the fulcrum to form practically a frictionless rolling surface on the tungsten

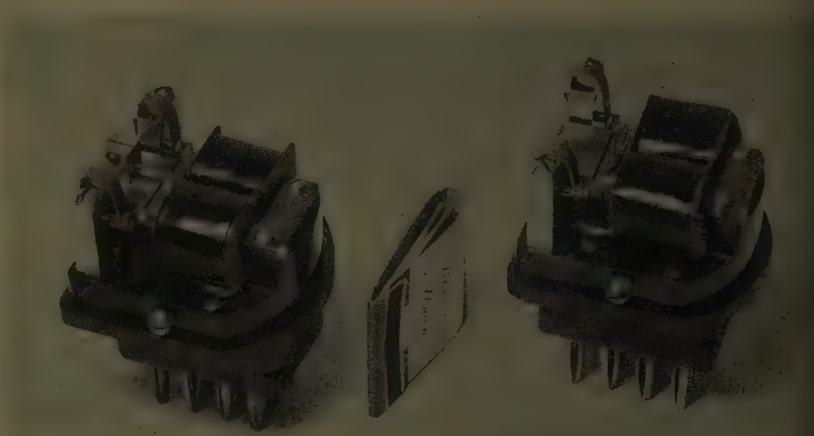

Figure 3. Prototype models of the 202-A type relay

arbide post. The usual jewel bearings nd closely fitting pivots which frequently re a source of trouble are not required. This construction produces a relay in hich the armature is balanced with respect to the pull of gravity as well as magetically, and permits the relay to be nounted in any position without the veight of the armature producing bias.

Another method of mounting the armture is shown by the relay to the left in igure 3 in which the armature is supported by a spring fastened at right ngles to the armature, resulting in a ombination of mechanical and magnetic ositioning of the armature. The spring upports the armature by longitudinal ension in the spring and hence can be lesigned for small stiffness if required for ome applications. This supporting neans results in a small longitudinal notion of the armature as well as the sual rocking motion in opening and losing the contacts. This construction produces a relay ubstantially free of bounce, since energy which must e dissipated to arrest the motion of the armature is aborbed in sliding friction at the contacts. Other comnonly used spring devices for producing bounce-free operation almost universally show deleterious resonance efects in the operating range or else are of such light contruction as to be impractical for reliable telegraph urposes. This relay, employing but a single spring for nounting and to implement the bounce-absorbing priniple, is quite free of the ill effects of mechanical resoance even with the relatively heavy contacts and large ontact spacing used in Western Union practice to mininize the need for attention. In addition, spring-mounting permits the relay to be designed for lower bankng currents, or as a 3-position relay by the use of various legrees of spring stiffness.

The *202*-type relay can be adjusted quickly and easily o meet a specified performance. There are no critical djustments involved; however, the air gaps between the aminations and pole shoe should be correct within about ±0.002 inch. The pole shoe is fixed in position when the elay is assembled. The resulting air gap between the rmature and pole shoe is not critical in value and need ot be changed during the life of the relay.

Figure 4. The functional components of the 202-A type relay

CHARACTERISTICS

In Western Union practice, the provision of the highest attainable sensitivity in a polar relay is usually of econdary importance since operating currents are rarely ess than 10 milliamperes. The operating current for most pplications is 35 milliamperes or more. Silicon steel aminations and soft iron armatures give satisfactory esults in this respect. Greater sensitivity can be had by he use of alloy magnetic materials, particularly in the pring-mounted type where the banking current can be educed to as low a value as is desirable by the application of a spring of appropriate stiffness. Of greater importance is a relay having a period of maintenance-free life in which adjustments are required at infrequent intervals only. These requirements have led to the general application of relatively large tungsten carbide contacts, about 3/16 inch in diameter, with a minimum spacing between contacts of 0.006 inch. The use of such heavy contacts and large travel distance make bounce-free operation difficult of attainment. However, due to a high natural resonance frequency of the armature, at most only a single relatively short bounce occurs in the pivot-mounted type. In the spring-supported type, bounce is virtually nonexistent at telegraph speed. Examination of the contacts, after many months of operation in high-speed circuits, generally shows the contact surfaces to be free of pits and material transfer. They usually have a somewhat polished appearance due to the slight sliding motion in the spring-mounted type and a tendency to move about slightly in the pivot-mounted type.

Due to the increased magnetic efficiency mentioned above, fewer turns are required on the coils than in the *17*-type relay, thus producing a relay of somewhat better characteristics at a lower impedance and much reduced size. The main line windings have been standardized at 2,800 turns which compares to 4,000 turns for the *17*-type relay. The corresponding d-c resistances and inductances are 140 ohms and 0.45 henry for the *202*-type, which compare with 290 ohms and 0.85 henry for the *17*-type. The a-c resistances at 60 cycles are 150 ohms for the *202*-type and 340 ohms for the *17*-type, an increase of about 7 per cent and 15 per cent respectively over the d-c values. The auxiliary windings have similar ratios.

Some details of the performance of the pivot type with silicon steel laminations and soft iron armatures are given in Figures 5, 6, 7, and 8. It will be noticed that in all respects the performance of the *202*-type is superior to that of the *17*-type. In Figure 5 is shown the relation between

travel distance of the armature at the contacts and banking expressed in ampere turns, which is also an inverse measure of the sensitivity. Curves are plotted for three polarizing intensities in the *202*-type, the standard value being 2,800 maxwells. As explained above, the sensitivity can be further increased by the provision of appropriate stiffness of the spring in the spring-mounted type, due consideration being given to the maintenance of sufficient contact pressure for a particular application. These curves then are typical of the minimum sensitivity available in the *202*-type relay.

The transit time (break-to-make) varies with the travel distance, the ampere-turn energization, and the waveshape of the operating current. The relation between travel distance and transit time for normal energization and square-wave signals is shown in Figure 6. The relation between energization and transit time for the standard travel distance of 0.006 inch is of the form shown in Figure 7.

Tungsten carbide has a higher contact resistance, particularly at low pressure, than other commonly used contact materials. It is important then that a relatively high contact pressure be maintained for all operating practices, a condition which is easily complied with in the *202* and *17* types of relay. The relation between energization and contact pressure is shown in Figure 8.

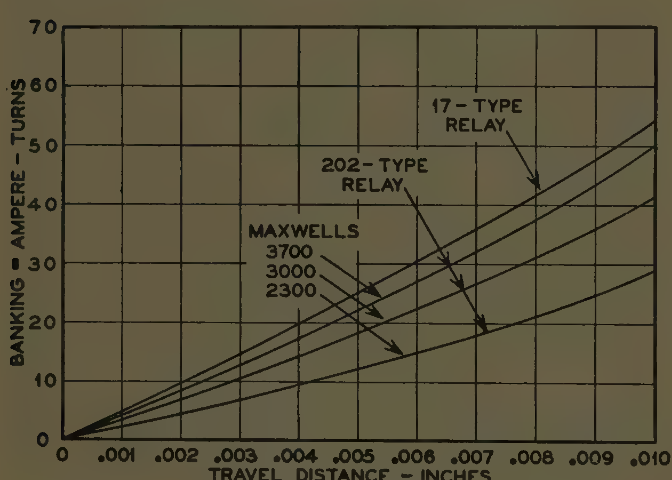

Figure 5. Relation between travel distance and banking

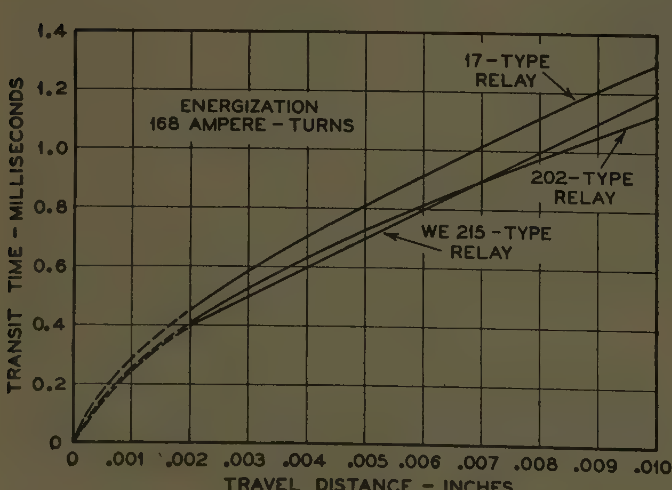

Figure 6. Relation between travel distance and transit time

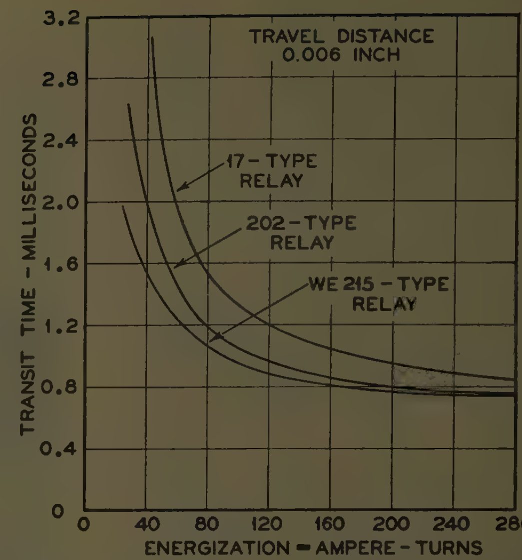

Figure 7. Relation between energization and transit time

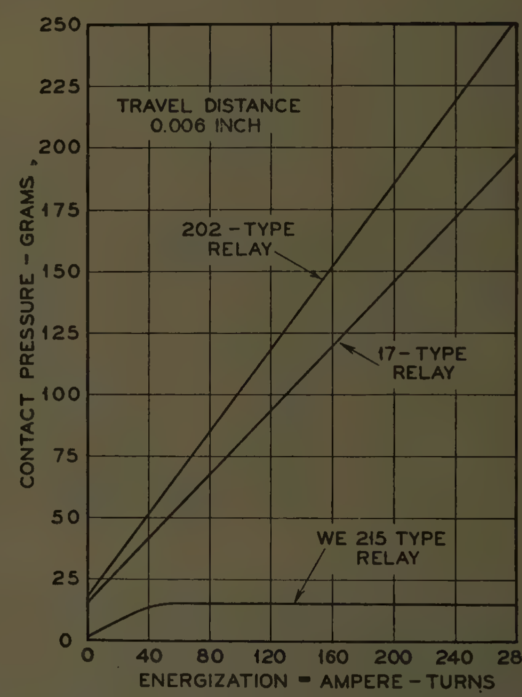

Figure 8. Relation between energization and contact pressure

The performance of this new relay, as indicated by prototype models, exceeds that of any previous relays of similar characteristics. Indications are that its cost will be small as compared to that of any existing relay of like ruggedness, dependability, and performance characteristics. Tests under actual working conditions in high-speed circuits have been entirely satisfactory, the results indicating that these relays will perform nearly a billion operations before readjustment becomes necessary.

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The Tracy Pumping Plant

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[T]HE TRACY PUMPING PLANT, now being com[-]pleted, is located on the Delta-Mendota Canal near [Tr]acy, Calif. It is one of a series of works to provide [an] adequate supply of water to the lower San Joaquin [Va]lley from the Sacramento-San Joaquin Delta. At one [ti]me a considerable acreage in this area was placed under [cu]ltivation by irrigation. Much of this irrigation was [fr]om wells which in time lowered the water table, depleted [su]pplies, and in some cases necessitated abandonment of [cu]ltivation. Diversion of water by the Friant Dam to the [u]pper San Joaquin has further reduced supplies available [to] the lower valley.

The water pumped by the Tracy Pumping Plant will be [ca]rried by the Delta-Mendota Canal to the Mendota Pool [an]d will be used to replace the depleted supplies in the [lo]wer valley and provide for placing additional areas under [cu]ltivation.

The installation in the Tracy Pumping Plant will consist [of] six pumps having a combined output of 4,600 cubic feet [p]er second under total dynamic head of 197 feet. Each [p]ump is driven by a synchronous motor. When irriga[ti]on facilities are fully developed, the maximum demand [fo]r water will occur in July and is expected to be about [4],250 cubic feet per second. The minimum demand, in [D]ecember, will be about 500 cubic feet per second. To [m]eet this varying demand it is expected that all six pumps [w]ill be operated in July and part of August, tapering [d]own to one pump during December and January, and [in]creasing to five pumps during April, May, and June.

The pumping plant is of the semioutdoor type having a [m]ain gantry crane mounted on the roof deck. The build[in]g is a reinforced concrete structure with a timber pile [fo]undation. It has an over-all length of 362 feet and [w]idth of 92 feet. It rises approximately 90 feet above its [fo]undations. The plant may be divided into two main [p]arts, the main pumping unit portion and the service bay.

Immediately adjacent to the Tracy Pumping Plant is [th]e Tracy switchyard and synchronous condenser station. [P]ower will be supplied from this yard at motor voltage for [th]e operation of the pumping plant. The main motor [c]ircuit breakers are located in the switchyard. Cables lead [fr]om these circuit breakers through a tunnel to the main [p]ump motors, an average cable run of approximately [1],000 feet.

The main pumps are of the vertical-shaft, single-impeller, [si]ngle-suction, centrifugal type rated 767 cubic feet per [s]econd at a total dynamic head of 197 feet. The pump [d]rive motors are of the synchronous, vertical-shaft type having a thrust and upper guide bearing located above the rotor and a guide bearing below the rotor. A direct-connected main exciter is located above the thrust bearing. The motors are rated 22,500 horsepower, 13,600 volts, 0.95 power factor, 3-phase, 60-cycle, 180 rpm. The motors are provided with voltage regulators of the rotating-amplifier type. The pumping units are designed to be operated as synchronous condensers with the pump operating in air.

Control and indication of unit operation are provided at the unit control boards on the pump floor. Limited control is provided also in the switchyard control building. The main control system includes voltage regulation, power factor, and equipment protection.

Each pump discharges through a butterfly valve, beyond which the six discharge pipes join in pairs to form three main discharge lines. These discharge through a siphon structure into the canal. The siphons are equipped with siphon breakers to prevent reverse flow following shutdown of the last of a pair of pumps.

Normal starting is at full voltage with the valve in the pump-discharge line closed and water in the pump. Normal shutdown is accomplished by first closing the discharge valve, thus preventing return flow. Emergency shutdown will be accompanied by reverse flow and reverse unit rotation. Although emergency shutdown initiates valve closure, maximum reverse speed will be attained before the valve closes which will be sufficient to restrict flow.

An interesting feature of the plant is the provision for removing pump parts without disassembly of the motor. This is accomplished by means of a combination pump gallery crane and hydraulic jacking frame which travels transversely of the plant on rails provided on the pump floor of each main unit bay. The jacking frame is capable of picking up the entire weight of the rotating parts of a pump, permitting uncoupling of the pump shaft from the motor shaft. The rotating parts of the pump then are removed individually. The pump gallery gantry crane removes these parts to the outside of the building from which point they are rehandled by the main gantry crane. The main gantry crane is used also to move the pump gallery crane from one pump bay to another. This method of removing pump parts will result in a considerable saving in the time required for pump maintenance, since it is expected the pumps will require disassembly for maintenance more often than the motors.

Water lifted by the plant will be conveyed by the Delta-Mendota canal in a southerly direction for approximately 117 miles to the Mendota pool. From this point, it will be distributed to approximately 1,000,000 acres of land, supplementing irrigation to half of the area, the other half being new land brought under irrigation.

[D]igest of paper 51-288, "The Tracy Pumping Plant—Central Valley Project, Cali[fo]rnia," recommended by the AIEE Committee on Power Generation and approved [b]y the AIEE Technical Program Committee for presentation at the AIEE Pacific [G]eneral Meeting, Portland, Oreg., August 20–23, 1951. Scheduled for publication [in] AIEE *Transactions*, volume 70, 1951.

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A Short-Haul Radio Communication Link Channelized by Time Division

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This pulse amplitude-modulated system was developed to fulfill the need for a short-haul low-cost communications link having a moderate traffic capacity. For this short-range operation, the microwave equipment has been simplified by eliminating many of the refinements necessary for trunk-line operation.

WESTERN UNION has had in operation for several years a number of microwave repeater circuits carrying telegraph traffic over paths several hundred miles long. These have proved very satisfactory and much has been learned and written about them.[1–5] It is foreseen that, in the extension of these circuits into a nation-wide radio beam network, there would be a definite need for a means to tie in and drop out blocks of traffic to localities off the main trunk route. Also, there are adjacent localities where telegraph traffic is sufficiently heavy or intervening terrain makes maintenance of cable circuits costly enough to warrant the installation of a single-hop microwave circuit.

For such short-range operation the equipment can be greatly simplified, eliminating such complexities as repeater relays, diversity receivers, and fault-locating circuits. In addition the use of relatively simple, low-cost channelizing techniques is possible. When this project was initiated in the early part of 1948, a study of different modulation systems[6] indicated that a pulse amplitude-modulated (PAM) multiplex terminal—which frequency modulates a radio frequency carrier—is a satisfactory combination for this type of service. These factors prompted the development of a short-range microwave relay with time division multiplex. The radio has a high-quality 100-kc modulation band which is subdivided by the time division equipment to provide eight 3,000-cycle voice bands. These voice bands are suitable for carrier telegraph, telephone, or facsimile operation and can accommodate as many as 160 duplex teleprinter circuits.

Figure 1. Front and rear views of the microwave terminal equipment

THE MICROWAVE EQUIPMENT

FIGURE 1 SHOWS the complete radio transmitter and receiver consisting of four panels: transmitter, receiver radio-frequency chassis, receiver intermediate- and video-frequency chassis, and a power supply. The power requirement is only 285 watts from a 115-volt a-c line. Line voltage stabilizers are not required, as all the high-voltage supplies include regulator circuits.

Each chassis has a cover panel which may be removed easily, giving access to various voltage regulator and gain controls. The meters and operating controls are mounted on hinged subpanels and protrude through holes in the cover panels. Although the equipment has been simplified to very nearly a practical minimum, extensive metering has been provided to facilitate maintenance.

The *2K56* reflex klystron was chosen for both transmitter oscillator and receiver local oscillator. This tube requires a beam voltage of only 300 volts at 30 milliamperes, keeping power supply size to a minimum. Its 200-milliwatt output in the range from 3,900 to 4,400 megacycles is probe-coupled into waveguide for efficient transmission to the antenna. A disc-dipole antenna with a 30-inch parabolic reflector, having a gain of 28 decibels, has proved satisfactory for optical paths of 20 miles.

The klystron is frequency-modulated by applying the intelligence signal to the repeller. The repeller voltage, klystron cavity tuning, and waveguide matching stub may be adjusted for maximum power output as indicated by a crystal detector coupled into the waveguide.

A small amount of the energy in the waveguide is coupled into two variable-tuned cavities which form a microwave discriminator. The d-c output from this is

Essentially full text of paper 51-346, "A Short-Haul Radio Communication Link Channelized by Time Division," recommended by the AIEE Committee on Radio Communications Systems and approved by the AIEE Technical Program Committee for presentation at the AIEE Fall General Meeting, Cleveland, Ohio, October 22-26, 1951. Scheduled for publication in AIEE *Transactions*, volume 70, 1951.

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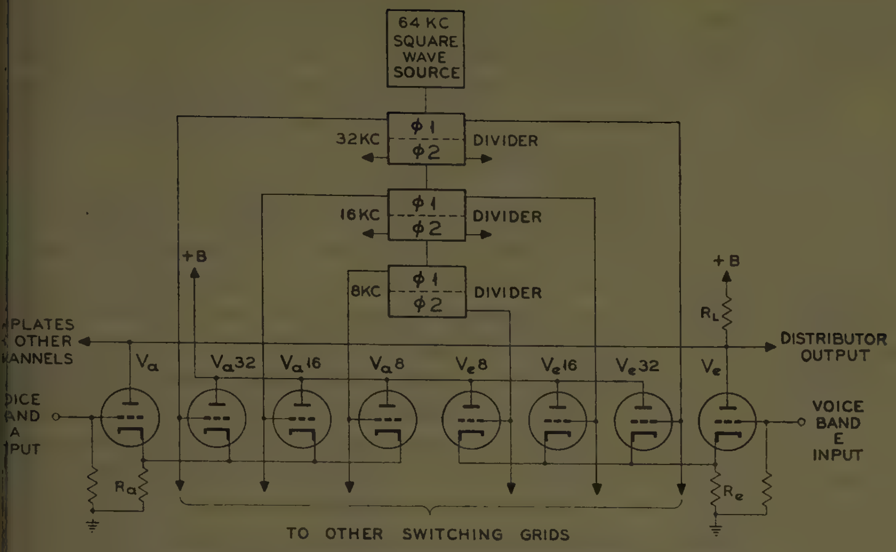


Figure 2. Simplified circuit of the electronic sending distributor

iplified and used to vary the repeller voltage, providing tomatic frequency control.

The receiver has waveguide feed from the antenna ough a preselector cavity to a waveguide crystal mixer ere it combines with the local oscillator signal to produce 32-megacycle intermediate frequency. A Wallman v-noise preamplifier is followed by a 4-stage inter-ediate-frequency amplifier and two limiter stages having -megacycle bandwidth. The discriminator is a modified ster-Seeley circuit with a bifilar-wound transformer. reference voltage obtained from the discriminator is d to change the repeller voltage of the local oscillator maintain a constant intermediate frequency.

The modulation recovered by the discriminator is plified by one stage and passes through a cathode lower into a 75-ohm cable to the pulse amplitude-odulation equipment.

THE PAM MULTIPLEX TERMINAL

HE 100-KC information band provided by this micro- wave circuit is a transmission medium of sufficiently gh quality to permit the application of time-division ultiplexing. The pulse amplitude-modulation method s chosen for this purpose, as previously mentioned, incipally because of its relative simplicity. In keeping th the low-cost nature of the system, the multiplexing rtion is constructed entirely of common, readily available mmercial components.

The electronic distributor developed for this system is sed on the principle of the binary code. A binary code ving n units will give 2^n combinations or distinctive code oups, so that for eight combinations a 3-unit code is quired ($2^3=8$). The three units employed in this rangement are square waves of frequencies 32, 16, and kc derived from a 64-kc crystal oscillator and a series of to-1 frequency dividers connected in tandem. Figure 2 a schematic diagram of this circuit.

For purposes of illustration, only voice bands A and E e shown. They enter the distributor via triodes V_a and respectively. The cathode of V_a is paralleled with the cathodes of three switching tubes V_a32, V_a16, and V_a8, so that when one or more switching tubes are conducting the resulting current flowing through cathode resistor R_a biases V_a beyond cutoff. This isolates voice band A from the distributor output load resistor R_L. If these three switching-tube grids are made negative simultaneously so as to prevent the flow of switching tube current through R_a, V_a becomes a normal self-biased amplifier and the signals on its grid appear at the distributor output. The switching tubes are controlled by the frequency dividers. Each divider has two outputs 180 degrees apart in push-pull fashion, designated as $\phi 1$ and $\phi 2$. Figure 3 illustrates the time and phase relationship of the number 1 and number 2 phases.

Note that there is only one interval during a revolution of the distributor where all three number 1 phases are negative simultaneously.

Observing in Figure 2 that the switching tubes associated with V_a are each connected to a $\phi 1$ output, it follows that V_a will become conducting only during this interval "A" to allow a sample of the intelligence on band A to appear at R_L. At all other intervals at least one of the three number 1 phases is positive, thus maintaining V_a biased beyond cutoff.

Voice band E operates in a similar fashion through triode V_e in conjunction with switching tubes V_e32, V_e16, and V_e8. But in this case a different "code combination" is set up on the switching tubes in that V_e8 is controlled by the number 2 phase output of the 8-kc divider. As a result, it is only during interval "E" of Figure 2(B) that all three tubes are cut off allowing a sample of the signal on channel E to appear at the output. Similarly by using the proper combinations of number 1 and number 2 phases

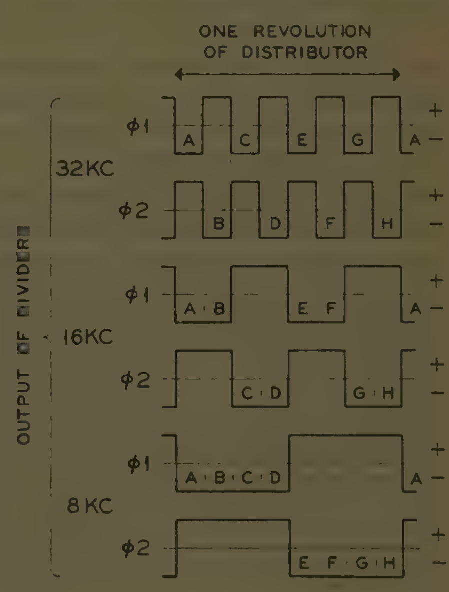


Figure 3. Output of the frequency dividers. The letters designate the portion of the time cycle devoted to each channel

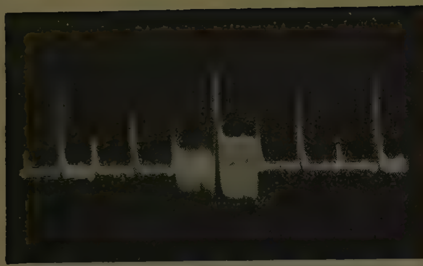


Figure 4. Sending distributor output showing two bands modulated

all eight voice bands can be sampled one at a time in logical sequence. Figure 4 is an oscilloscope picture of the distributor output covering about one revolution with band D modulated by speech and band E carrying a 1,000-cycle tone.

The receiving distributor employs the same principle of operation, as shown in Figure 5. Here the switching elements are crystal rectifiers instead of triodes but they perform the same function. The incoming samples arriving at the signal input appear on all eight grids simultaneously, but, since only one triode at a time is conducting, only the voice band associated with that triode receives the signal. Thus, when the A voice band sample enters the distributor, only V_a is in a conducting condition to pass the sample to the A voice band output, and similarly for all other voice bands.

The driving frequency for this system is derived from a 64-kc crystal oscillator in the transmitter, the output of which is amplified and clipped to produce a square wave. Observing Figure 6, which is a functional block diagram of the system, it can be seen that this frequency is used to drive a series of four cascaded 2-to-1 frequency dividers producing square waves of 32, 16, 8, and 4 kc. The output of the 4-kc divider is passed through a narrow-band filter and applied to the input of channel A to provide a register signal. Since this tone is above the response range of the channel, it may be sent along with the channel intelligence without causing interference. The 32, 16, and 8-kc dividers produce the switching frequencies used to drive the electronic distributor as previously explained.

The pulses, as they leave the sending distributor, are not suitable for transmission. First, the pulses are too wide so that in being sent through a transmission medium of restricted bandwidth they would be broadened further and excessive pulse overlap would result, with corresponding crosstalk. Secondly, all of the pulses do not have the same shape, and thus they may be differently modified by the transmission medium. For this reason, the pulses are passed through a synchronous gate which operates at 64 kc. The gate selects a small portion toward the end of each pulse for transmission. The portion selected is shown in Figure 4 by the two small pips or notches appearing on each pulse. The gate, at the same time, introduces a small amount of the 64 kc into the signal. The 64-kc component is transmitted along with the signal frequencies and is used to drive the distributor at the receiving end. Referring to Figure 7, the distributor output is applied to the grid of V_1. A 64-kc keying wave of large amplitude and proper phase is applied to the grid of V_2. The keying wave is so controlling that its amplitude, when positive, is sufficiently large to cause the cathode current of V_2 to bias V_1 beyond cutoff; and when negative, to permit V_1 to perform as a normal amplifier. The outputs of V_1 and V_2 are as shown at C and D, and being 180 degrees out of phase they can be subtracted to control the magnitude of the 64-kc component in the output signal. Rheostat R is provided for this purpose.

The pulse train now consists of short, separated pulses of uniform shape and duration, together with the required amount of 64 kc as shown at E. High-frequency switching components are also in evidence, and as they convey no essential intelligence, are removed by a 64-kc low-pass filter to give the waveform shown in Figure 8. The pulses now have a more sinusoidal shape, and after amplification are ready for transmission. In the illustration shown, channel D is being modulated by voice, and channel E is carrying a single frequency. Channel A can be identified by the 4-kc registration signal on its pulse.

Referring again to Figure 6, it is seen that at the receiving terminal the incoming pulses are amplified and again filtered by a 64-kc low-pass network. This is to remove any high-frequency noise components which may be present in the transmission medium. Inspection of Figure 9 shows that the incoming signal pulses have been further broadened in traversing this filter and considerable overlap is evidenced which, if left uncorrected, would cause crosstalk between adjacent channels. For this reason, and also because the transmission medium may have introduced some modification of the pulses, a means for reshaping and reconditioning them must be inserted before they reach the receiving distributor. This is accomplished by means of an adjustable signal-shaping amplifier which consists essentially of a phase shifter and a differentiating circuit. By varying the time constants of these circuits it is possible to compensate the effects of phase distortion introduced by the transmission medium and line filters.

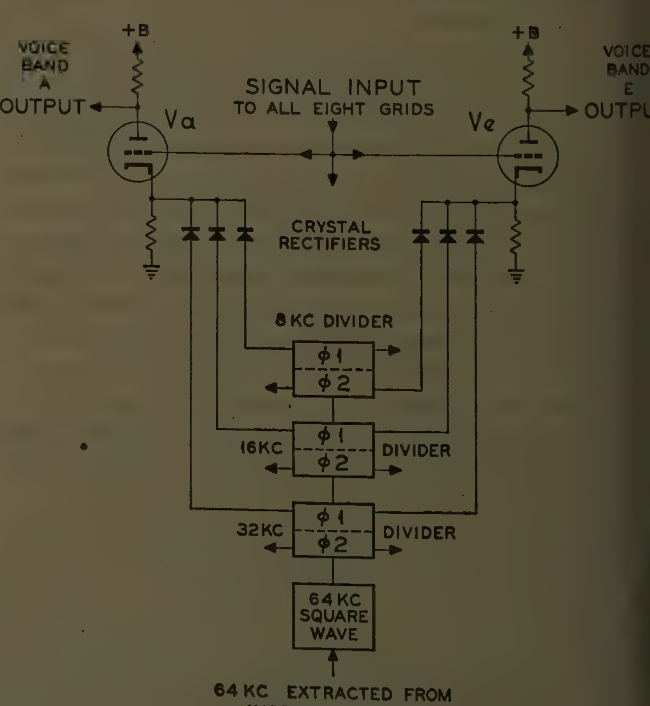


Figure 5. Schematic of the receiving distributor

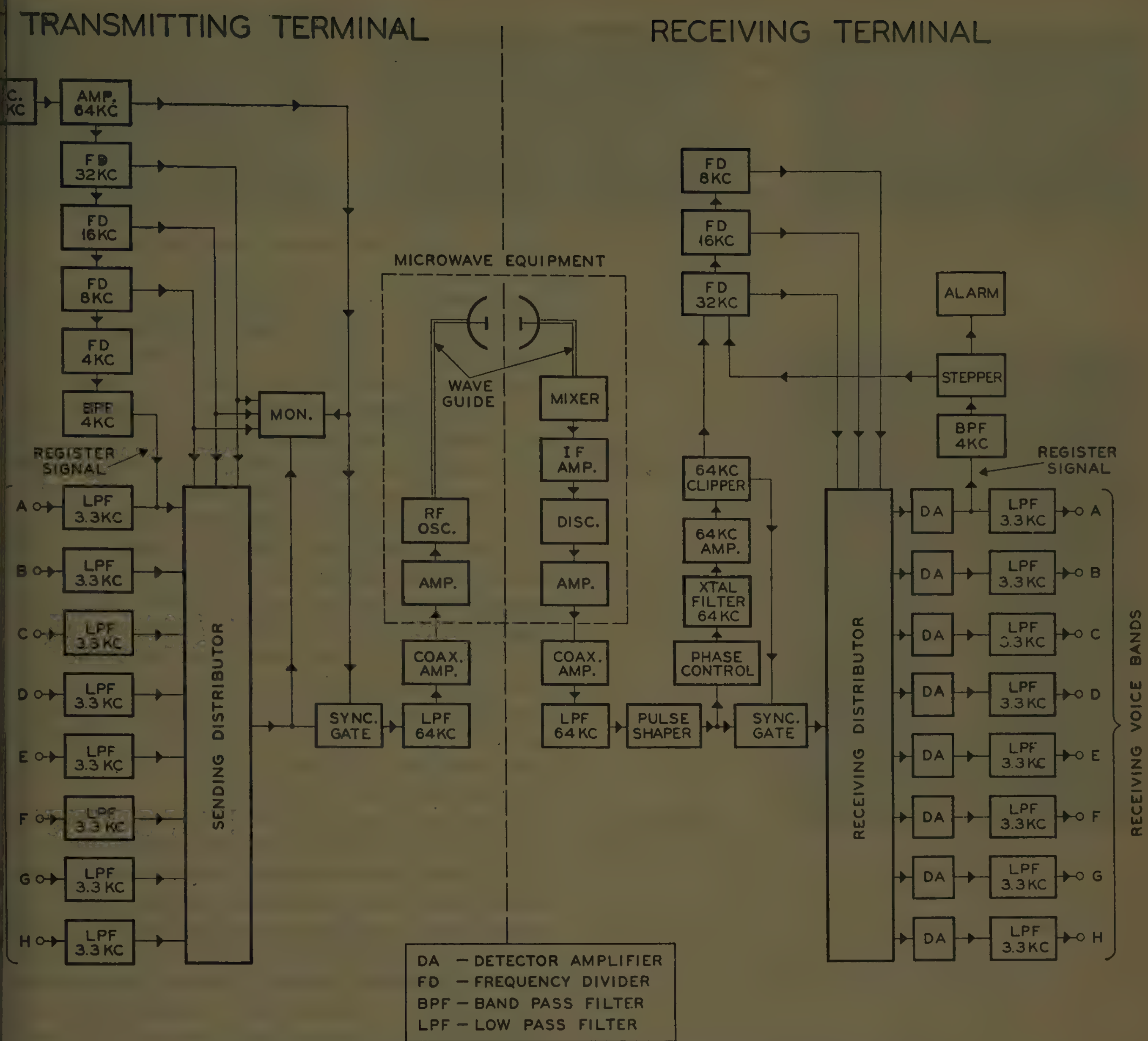


Figure 6. Functional block diagram showing both sending and receiving terminals

Next it is necessary to recover the 64-kc component roduced at the transmitter for driving the receiving minal. This is accomplished by passing a portion of the oming signal through a phase shifter and a 64-kc crystal er. The filter has an extremely narrow passband, and noves all components of the received signal except the kc. After amplification this 64-kc component is clipped produce the required square wave for driving the 32-, , and 8-kc frequency dividers which in turn control the eiving distributor. Now back to the intelligence signal. The reshaped pulses enter the synchronous gate which erates similarly to that at the sending terminal. Here, wever, the gate functions to select a small portion at the se center. Figure 10 shows the pulses as they appear the output of the pulse shaping amplifier. The small ches occurring at the center of the pulses indicate the e at which the synchronous gate operates; and since occurs at the point of greatest amplitude, it affords best margin against interference. The timing of the gate operation in relation to the incoming pulses is determined by the phase control previously referred to. It can be seen that although the pulses still do overlap somewhat they have been shaped so as not to extend into the gating period of the adjacent channels, thus preventing crosstalk. The pulse train as it appears after the gating operation is shown in Figure 11. These pulses are now properly conditioned to enter the receiving distributor.

The output of one modulated channel as it appears at the receiving distributor is shown in Figure 12. The pulse appears once during each revolution of the distributor, or every 125 microseconds, the time between successive pulses being divided up among the other seven channels. The wide portion of the pulse, or pedestal, represents the time during which the particular channel is in the operative condition. The narrow portion is the actual modulated signal pulse. Obviously this little pip represents only a very small amount of power, and so must be built up to be of any use. This is accomplished by means of a holding

or "pulse stretching" circuit which functions to increase the average voltage. It is thus possible to start filling in the blank spaces between successive samples. Figure 13 shows the same modulated pulse as it appears at the output of the pulse stretcher where the power has been substantially increased. From here the signal is amplified further and passed through a 3.3-kc low-pass filter which removes all switching and other high-frequency components

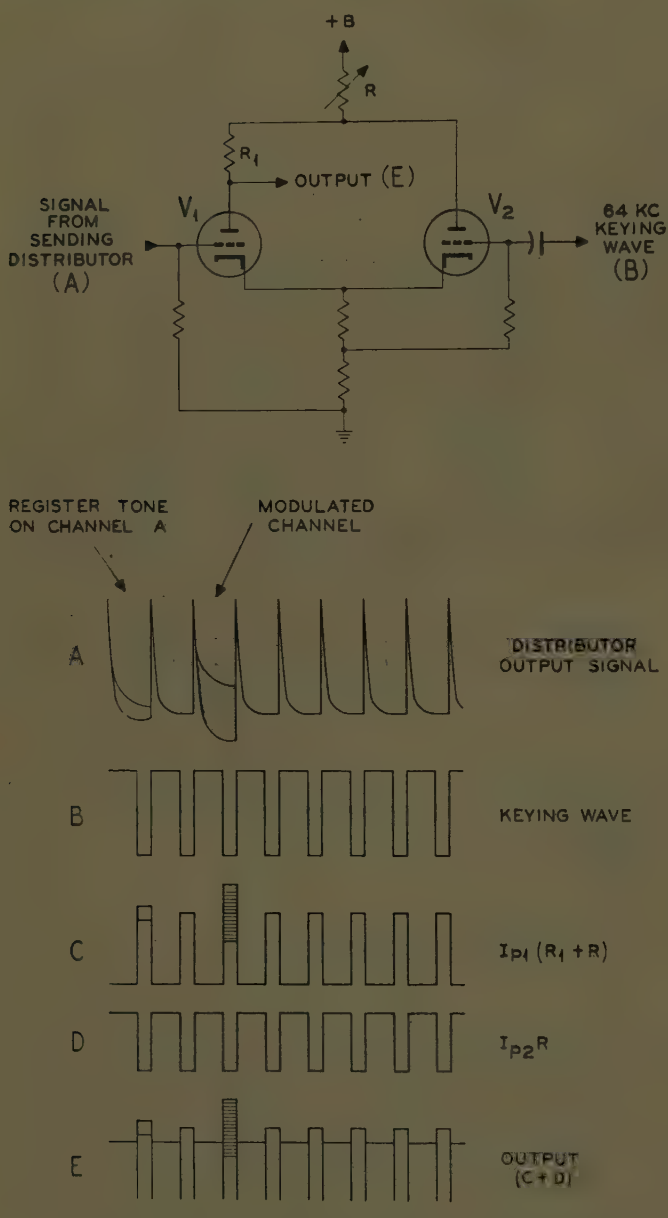


Figure 7. Synchronous gate circuit and waveforms

leaving only a replica of the original voice-frequency signal

The system as it stands now will function as a communica tions circuit, but there is no guarantee that a signal enterin voice band *A* at the sending terminal will appear at th *A* band jack at the receiving terminal. It is therefor necessary to provide a means for correcting the channe alignment of the two terminals. It will be remembere that an identifying tone (4 kc) was superimposed on the band at the sending terminal, and this is used to contro the operation of a multivibrator. This multivibrato operates at about 100 cycles and introduces a sharp kic at the input of the 32-kc frequency divider at each reversal causing an extra operation of the divider which advance the receiving distributor one segment or channel. Th receiving distributor thus will advance channel by channe at a 100-cycle rate until proper registration of the dis tributors is reached. The channels are now momentaril in alignment so that the 4-kc registration frequency wi appear at the output of the 4-kc band-pass filter associate with the receiving side of band *A*. This tone is amplifie and detected to apply a negative bias to the multivibrator thereby halting its operation and leaving the terminals i registration. The entire scanning operation requires les than 1/10 second. Inasmuch as registration will be mair tained only when the 4-kc tone is present on the output band *A*, the same negative bias is also used to prevent th operation of audible and visual alarms. Thus loss registration for any reason will be called to the attention operating personnel immediately.

A monitor is provided at the transmitting terminal fc use in checking the output of the sending distributor. Th circuit employed corresponds to one channel of the re ceiving distributor, including a stretcher amplifier an output filter. An 8-position switch connects the grids three switching triodes to various combinations of th 32-, 16-, and 8-kc frequency dividers corresponding t bands *A* to *H*. The operation of the monitor thus can b adjusted to coincide with the operation of a particula channel and permits monitoring of the traffic thereon.

The finished PAM terminal is a completely self-containe unit embodying sending and receiving multiplex unit power supply, monitoring and testing facilities, and failur alarm all mounted in a single cabinet rack about 7 fee high and less than 2 feet square. Figure 14 shows th cabinet as viewed from the front and rear. The use miniaturized components throughout the terminal and th adoption of other construction techniques have resulted i a very substantial saving in space over present frequenc division systems of equal traffic capacity. The origina

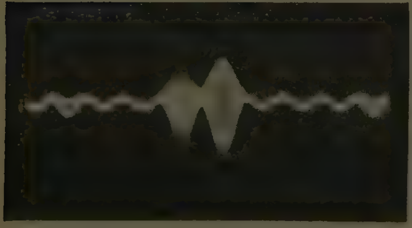


Figure 8. Pulse train as transmitted

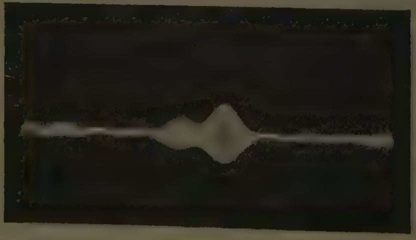


Figure 9. Received pulses before reshaping

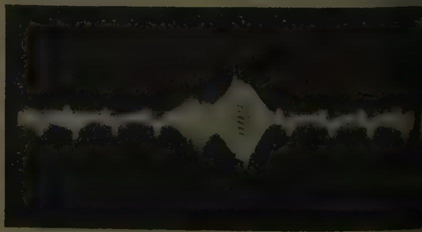
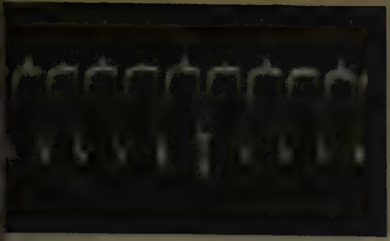


Figure 10. Reshaped pulses



igure 11. Pulse train after gating

Figure 12. Receiving distributor output of one voice band

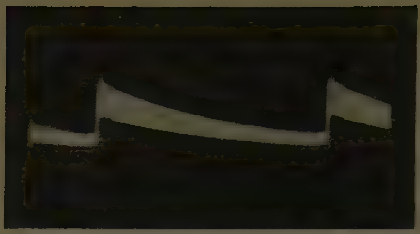


Figure 13. Output of pulse stretcher

totype model was completed in October 1949 and has n undergoing tests since that date.

everal of these terminals have been constructed to date l they have been substantially uniform in performance. h the sending and receiving terminals on a back-to-k basis, noise and crosstalk are down at least 50 decibels s multichannel signal to rms noise) on all channels. liminary tests conducted over the short-range radio-m circuit between New York and Newark have given sfactory results. These tests were made using only one M terminal located in New York and with the Newark io terminal on a looped-back basis to form a 1-repeater io relay link. The signal-to-noise ratios obtained under se conditions were 40 decibels or better on all bands. ther tests are under way to check the life expectancy he various components and to aid in formulating a pre-tive maintenance routine.

Figure 14. Front and rear views of the PAM terminal assembly

CONCLUSIONS

SAVINGS IN initial cost of about 50 per cent and a re-duction in size and weight of about 75 per cent can realized over frequency division systems presently in-lled in the telegraph plant. These savings are due in ge measure to the use of miniaturized components and application of new construction techniques. Even en compared on an equal footing, however, the PAM em should still show an appreciable savings due to a uction in the number of filters required.

he substitution of electronic components for filters, le reducing the initial cost, creates a more expensive intenance problem because the stability and useful life passive networks are far superior to that of electronic nponents. The compact construction facilitates the inary maintenance adjustments which can be accom-hed simply using only a decibel meter, a handset, and a wdriver. Trouble shooting, however, requires rather borate testing instruments. Generally speaking, a em of this nature is functionally more complicated and tains more critical factors than frequency division equip-nt. It therefore requires more attention and demands the attendant a more specialized knowledge of the ory and operation of the system.

he transmission bandwidth required for a pulse system this type depends upon the amount of pulse overlap ch can be corrected readily to prevent interchannel sstalk. In practice this works out to be about twice spectrum interval required for an equivalent frequency ision system. If pulse transmission is confined to a rower bandwidth, the crosstalk problem becomes reasingly difficult. A frequency division system now in use derives eight voice bands from a bandwidth of 30 kc, whereas this PAM terminal requires a nominal band-width of 64 kc to provide the same capacity. Furthermore, a very gradual cutoff above 64 kc is employed in the line filters to insure a satisfactory wave shape in the received pulses. Hence the system occupies the range to about 100 kc in the sense that the spectrum below this frequency cannot be used for any other purpose.

Pulse systems require a transmission medium possessing a high degree of phase stability, which precludes their use on ordinary wire lines. Radio beam circuits are ideal for the purpose. They provide broad transmission bands so that spectrum economy is of secondary importance, particularly for short distances. This microwave radio-PAM combination offers a satisfactory, economical means of handling moderate traffic loads on a short-haul basis.

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Improving the Sensitivity of Switches with Linear Feedback

J. J. BARUCH

The sensitivity of reversible switches can be adjusted to varying degrees by using a suitable linear feedback coefficient. Maximum sensitivity depends on the characteristic curve of the switch, and methods are presented for determining this maximum and the feedback coefficient needed to achieve it.

A SWITCH WILL BE defined in this article as a network whose output changes from a value below one state to a value above another when its input is changed from one state to another. In switching problems, as opposed to ordinary amplifier problems, the main considerations are the end states of the output compared to the end states of the input. The path taken by the output in its transition from state to state is of interest only to the extent that it determines the distance between input states. In general, the switch is a nonlinear active or passive network.

While the two curves of Figure 1 look very different, in each case a transition from input state S_1 to input state S_2 produces a transition in output from state R_1 to state R_2. The natural reaction to calling both of these systems "switches" is one of doubt. It is apparent that Figure 1*B* describes a "better" switch than Figure 1*A*. The fact that *B* is intuitively "better" as a switch demonstrates a prime factor in the design of most switches—the desire for maximum switch sensitivity. If this sensitivity is signified by σ, then σ may be expressed as

$$\sigma=\frac{R_2-R_1}{S_2-S_1} \tag{1}$$

The only switches considered in this article are reversible ones; that is, switches whose output may be transformed from state R_1 to state R_2 and back by a suitable change in input. Thus, the range S_2-S_1 will be considered as that range through which the input must change to take the output from R_1 to R_2 and back to R_1. While this range in some cases may be the same as that required to take the output from R_1 to R_2, for hysteretic switches this will not be true. In the general problem of switch-controlled mechanisms, it is this rang of reversibility which is c prime importance.

It may seem odd to regar any network having a transfe function as a switch. But switch is a switch because c the way it is used, not be cause of any inherent qualit of the mechanism. Thus, if any transfer function is description of the path along which the output goes fro R_1 to R_2 as the input goes from S_1 to S_2, any network havin such a transfer function may be considered a switch. Th reason that this generalization is not observed in practic is that other specifications are put on the switch such a power gain, snap-action, high sensitivity, state stability and so forth.

RELATION TO AN AMPLIFIER OR MODULATOR

THE ESSENTIAL difference between an amplifier and switch is one of linearity. An amplifier usually required to produce an output which is a faithful replic of its input. When the input is changed from S_1 to S the output must change from R_1 to R_2, but the path travelle in this transition generally is restricted to a straight lin In the switch, only the end-points of the transition are interest. While something might be said about th frequency response and time delay of the two systems, th present discussion will be confined to a study of the quas static response of switches. The input will be assumed vary so slowly that the departure of the system fro equilibrium will be negligible at all times. Thus, n mention of time effects will be made.

With the linear amplifier considered as a switch, th amplifier gain K is equivalent to the switch sensitivity Thus the transition from R_1 to R_2 is made with an inpu transition of S_1 to S_2 where S_2 is given by

$$S_2=S_1+\frac{R_2-R_1}{K}$$

Since the state-to-state transition is a reversible phenomeno in the linear amplifier the input interval for a change fro R_1 to R_2 is the same as the interval for the transition fro R_2 to R_1. Figure 2*A* illustrates the linear portion of a amplifier's characteristic. Under this condition, the sens tivity of the switch is indeed K. The characteristic ha

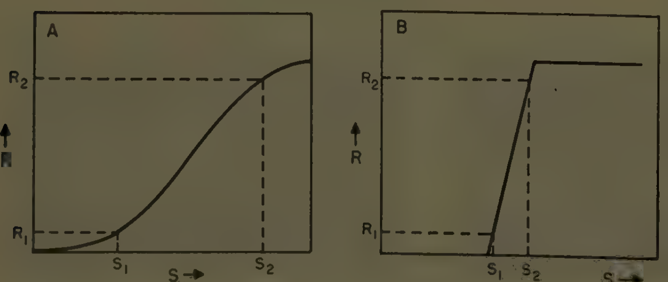

Figure 1. The transfer characteristics of two switches

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assumed to be a mathematically straight line over the on shown, and the nonlinear portions of the response been deleted to avoid confusion.

troducing regenerative feedback around the amplifier affect its response. If K is the gain of the amplifier out feedback and K' is the gain with feedback, the liar equation for gain is

$$\frac{K}{1-K\beta} \quad (2)$$

e β has the dimensions of S/R and signifies the number nits of stimulus produced at the input, in addition to applied stimulus, per unit of response. In the case of ltage amplifier, β is a dimensionless quantity, both S R being measured in volts.

uation 2 indicates that the gain K' can be increased out limit, approaching infinite gain as β approaches For the case of an amplifier having a true linear onse over a finite region of output, making β equal to will result in an infinite gain over the same finite on of output. The reason for specifying the range of ut rather than the range of input will be made clear later section. Figure 2B depicts the performance of a h obtained by using a β equal to $1/K$. The sensi- of such a switch is also infinite so that any change imulus about the value $S_1=S_2$ will produce a discrete in response.

fore concluding that all switching problems are d when a linear amplifier has been discovered, consider change in sensitivity as the uncompensated gain K ges. In an amplifier with an uncompensated gain 00, and a β of 0.01, a 10-per cent decrease in K will uce a decrease in sensitivity from infinity to 900. , a switch which once needed any finite change in t to produce a change in output of, let us say, 50 volts d now require an input change of 55 millivolts.

consideration will be given at this point to the ition of feedback where $\beta=1/K$. A discussion of the hing behavior under this condition requires an ysis of the nonlinear portion of the curve as well as inear. As a result, the subject will be covered in the wing section.

SINGLE-VALUED NONLINEAR FUNCTIONS

PRACTICAL operation, an ideally linear amplifier is a esently unattainable goal. While amplifiers usually treated as linear systems, the specifications of an ifier generally read "total harmonic distortion less n per cent" where n is a value dependent on the cular amplifier. This case is not concerned with quantities as harmonic distortion, but rather with the ature of the output versus input curve. Most other es capable of producing a "power gain" (that is, ulators) also have curved characteristics. It may take derable magnification and careful experimentation etermine the curvature, but it usually can be found. me cases (such as the thyratron) this curvature may t from time integration of a statistical uncertainty, other cases simply from a saturation of some of the onents.

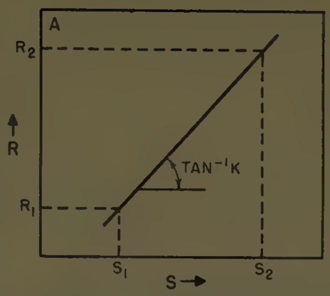


Figure 2(A). Characteristic of a linear amplifier

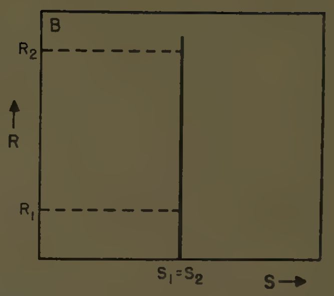


Figure 2(B). Linear amplifier with optimum feedback

A typical characteristic of this form, the S curve, was shown in Figure 1A and is redrawn in Figure 3A. This curve might be a plot of output versus input for a d-c amplifier, the output current through a carbon stack as a function of input pressure, or the net force on a blocked relay armature as a function of input current. The problem to be treated now is how this curve changes as feedback is applied to the system.

If the response is any arbitrary function of S, the stimulus, then

$$R=f(S) \quad (3)$$

If R_c is the response of the compensated system having a per-unit feedback coefficient β, then

$$R_c=f(S+\beta R_c) \quad (4)$$

The problem of the amount of feedback necessary to provide an infinite slope at any point on the original curve may be solved thus

$$\frac{dR_c}{dS}=\frac{df(S+\beta R_c)}{dS}$$

$$\frac{dR_c}{dS}=(f')\left(1+\beta\frac{dR_c}{S}\right)$$

whence

$$\frac{dR_c}{dS}=\frac{f'}{1-\beta f'} \quad (5)$$

where f' is the derivative of the function f with respect to its argument. Equation 5 is a more general form of equation 2. The gain, K, in equation 2 is the slope of the linear portion of the curve corresponding to f' in equation 5. The compensated gain, K', is the new slope corresponding to dR_c/dS. Equation 5 shows that the compensated slope at a point having an uncompensated slope of f' may be made infinite by using a β equal to $1/f'$. This is the condition which occurred in the case of the linear amplifier.

Before proceeding further in the analysis of the nonlinear system with feedback, it would be well to work out a simple method for performing the analysis. A graphical method has been worked out for doing this and will be presented here. While the method may not be new, the writer has not seen it used in any analysis of feedback problems, although it provides an insight into the use of feedback as a linearizing method, as well as a method for improving switching operation. If in equation 4 β is assumed to be

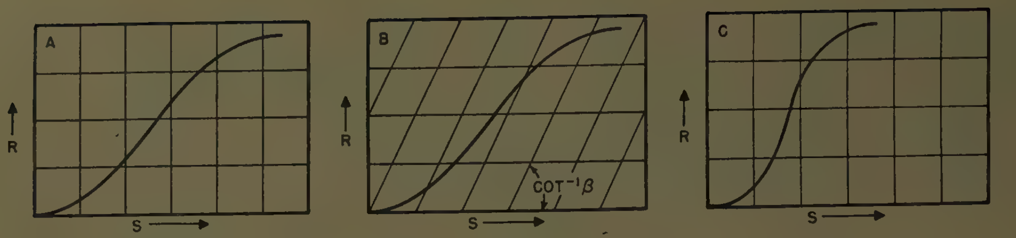


Figure 3(A). A typical S curv response characteristic

Figure 3(B). S curve respons with feedback on skewed co ordinates

Figure 3(C). Curve B redraw on Cartesian co-ordinates

a constant independent of R, the feedback is linear. Equation 4 describes the physical phenomenon as follows: "Any value of response, R, previously occurring at a value of stimulus S' now occurs at a new value of stimulus S which is smaller than S' by an amount equal to βR." Equation 4 may be represented graphically. If a point on the uncompensated curve has the co-ordinates (R, S'), the introduction of feedback causes that point to take on the new co-ordinates drawn through the point (R, S') and intersecting the S axis at an angle given by

$$\theta = \cot^{-1}\beta$$

The point of intersection Q of this line with the S axis is given as

$$Q = S' - R\cot\theta$$

or

$$Q = S' - \beta R$$

Thus the point Q has the same value as the new point S. To analyze the effect of feedback on a curve made up of points in the SR plane it is only necessary to draw a set of lines making an angle with the S axis of $\theta = \cot^{-1}\beta$. Figure 3 demonstrates this construction. Figure 3A is the typical S curve drawn in the SR plane using orthogonal co-ordinates. In Figure 3B, the ordinate lines have been skewed to the right through an angle $\phi = \tan^{-1}\beta$. The horizontal spacing between the skew lines has not been changed, nor has the vertical spacing between the horizontal lines. R and S are still measured perpendicularly to each other, but the lines of constant S have been skewed. The shape of the curve has not been altered from its original shape. Figure 3B now describes the operation of the system of Figure 3A when used with a regenerative feedback coefficient of β. Figure 3B may be used as it is, or for qualitative determination of the performance it may be redrawn in Cartesian co-ordinates as shown in Figure 3C. Here the change in shape resulting from the addition of feedback is readily apparent.

Such factors as the generation of an infinite slope, a negative slope, or a multivalued function from the original curve may be studied from the co-ordinate transform shown in Figure 3. For example, the specification of infinite slope at some value of R means that the curve shall be tangent to a line of constant S at that value of R. To determine the value of feedback necessary to produce this effect, it is only necessary to draw a tangent to the curve at the value of R and use a feedback coefficient equal to the inverse slope of the tangent line. The operation, expressed mathematically, is that $f'\beta = 1$, which is the same criterion previously developed.

In many cases it will be desirable to have an infinite slope at some specific value of stimulus rather than response. In this case, the graphical construction begins with straight line intersecting the stimulus axis at the poin (O,S), where S is the value of stimulus at which we wis an infinite slope. The line is now rotated about the poin (O,S) until it lies tangent to the curve. Using the invers slope of this line as β, the point of infinite slope will occu at a stimulus value equal to S. The reasoning behind th operation is as follows. Since the tangency point and th point (O,S) lie on the same skew line, introduction of feedback coefficient of β will cause them to have the sam value of S, and will simultaneously cause the tangenc point to become a point of infinite slope. The only poin on the S curve which may be made to have an infinit slope, and still retain the single-valued nature of the curve is the point of inflection, which is also the point of maxi mum slope. However, the effect of increasing the feed back beyond the value necessary to bring the inflectio point to infinite slope can be determined.

Figure 4 illustrates the same S curve with different value of feedback. Figure 4C and 4D represent curves showin the effect of the amount of feedback just necessary t produce an infinite slope at the inflection point; A and illustrate the effect of less feedback; while E and F illustrat the effect of a larger amount of feedback. These last tw figures are the main point of interest in the present discu sion. The increase of feedback has resulted in R becomin a multivalued function of S. As the stimulus is increase from O, R increases slowly until the point S_2 is reache At this point, any increase in S produces a discontinuou jump in R to a high value. As S is reduced from abov S_2 the response decreases slowly until point S_1 is reached which value R drops discontinuously to a value near zer

The two desired states have been marked as R_1 and on the first pair of curves yielding a stimulus interval $S_2 - S_1$. The same values of R_1 and R_2 result in a small range of stimuli in the second set of curves because of th increased feedback. In the third set of curves, howeve the stimulus range necessary for a reversible transfer be tween states has increased to the value shown. When th stimulus advances to a value just above S_2, the respon jumps to above R_2 and similarly, with reduction, th response drops to a level below R_1. While the hysteret switch shown yields a sharp snap-transfer from a low sta to a higher state, it is a relatively poor switch where sens tive reversibility is desired.

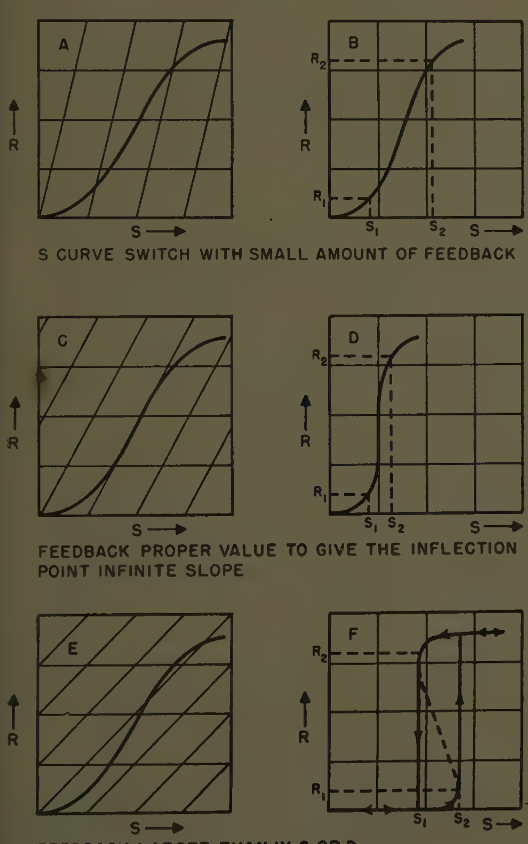
The increase of sensitivity and its subsequent decrea with a steadily increasing coefficient of linear feedba indicates that the performance of a switch as a functi of the degree of feedback might be optimized. For th S curve response so often typical of practical circuits, th optimization may be carried out readily. Since, in gener the uncompensated response curve is determined expe

ntally rather than known analytically, a graphical hod of optimization will be described. There are two ibilities: the first with the responses on opposite sides he point of inflection, and the second with them on same side.

n Figure 5 the S curve and the two desired response es have been drawn. Points 1 and 2 are the points on curve having R co-ordinates of R_1 and R_2. The vertical s through 1 and 2 are separated by a distance D_0, the essary stimulus range in the absence of feedback. If se vertical lines are now rotated clockwise about points nd 2, the horizontal distance between them will decrease. a matter of fact, the horizontal distance between them is

$$D_0-(R_2-R_1)\cot\theta$$

ere θ is the angle between the skewed line and the izontal and $\cot\theta$ equals the coefficient of feedback for condition represented by the skewed lines. This rease in spacing continues until the line through point 1 omes tangent to the curve. The horizontal spacing ween the lines D_1 now corresponds to the stimulus range essary for the reversible transfer with the indicated dition of feedback. If rotation of the lines about points nd 2 were continued, the line through 1 would cut the ve twice, and the horizontal spacing between the lines uld no longer indicate the required stimulus range. e reason for this fact is apparent. A reduction of nulus from point 2 with this greater amount of feedback uld result in a transfer to below state R_1 only after the nulus had decreased to correspond to that point on the



gure 4. Typical curves with varying amounts of feedback

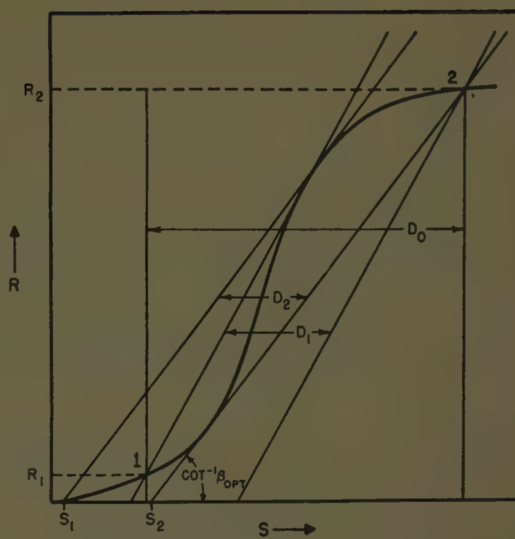


Figure 5. Graphical determination of optimum feedback coefficient

curve having infinite slope. It would not occur at the intersection of the line through point 1 and the curve. The lines may be rotated further, however, provided that a different set of rules is obeyed. After the line through 1 has become tangent to the curve, it is rotated in such a manner that it remains tangent to the curve. Thus, the line always coincides with the curve at the new point of infinite slope, and the horizontal distance between lines is equal to the necessary stimulus range. The distance between the lines will now continue to decrease as they are rotated until the line through point 2 also becomes tangent to the curve. This statement is true as long as point 2 is above the point of tangency of the line through point 1. If the line through point 2 had become tangent first, it would still be true if point 1 lay below this point of tangency. The reason for this is that the line through point 2 remains at point 2 during this rotation, and the other line rolls along the curve and approaches point 2 along a horizontal at a rate given by

$$dD/D=(R_2-R_T)\csc^2\theta-\rho\cos\theta$$

where ρ is the radius of curvature at the point of tangency. For negative radius of curvature dD/D is positive, (that is, D decreases as θ decreases) as long as R_T, the value of R at the point of tangency, is smaller than R_2. A similar equation can be written for the alternate condition.

This decrease in stimulus range will continue until the line through point 2 becomes tangent to the curve. The resulting horizontal separation will be D_2. This distance will be the minimum range of stimulus which can transfer the system from state R_1 to state R_2 and back using linear feedback. The reason for its being the minimum is that line 2 as well as line 1 must now be rolled along the curve. Measuring the horizontal distance between the lines at the point of inflection shows that the number 1 line has its point of tangency above the point of inflection (as indeed it must if point 1 were originally below the inflection point) so that, as it rotates, its intersection with the line $R=R_t$ moves to the left of the inflection point and its

distance from the point of inflection increases. Similarly the intersection of line 2 with $R=R_t$ must move to the right of the inflection point and its distance from the point of inflection increases. These lines must be on opposite sides of the curve at the point of inflection from the original condition that points 1 and 2 be on opposite sides of the point of inflection. From this fact, the distance between them is the sum of the distances of their intersections with $R=R_t$ from the point of inflection. Since both of these distances increase as θ decreases, D must increase and D_2 must be the minimum attainable stimulus range by means of linear feedback. The optimum amount of feedback is

$$\beta_{opt}=\cot\theta_{opt}$$

In practice it will be unnecessary to perform all this rotation. To find the optimum amount of feedback necessary for reversible transfer, knowing point 1 and point 2, it is only necessary to draw line 1 through point 1 tangent to the curve and draw line 2 through point 2 also tangent to the curve. The optimum feedback coeffici is the inverse slope of the more nearly horizontal li (that is, the greater value of β). The stimulus range m be determined by drawing another line parallel to t selected line and also tangent to the curve on the oth side of the inflection point. The horizontal spacing b tween these lines is the minimum stimulus range, and t intersection of these lines with $R=0$ axis are the valu of stimulus at which transfer takes place. The horizon distance D_2 and the stimuli S_1 and S_2 demonstrate th quantities in Figure 5.

Reducing the vertical distance between points 1 and would also decrease the required stimulus range. general, however, the distance between the points is fix by the application to which the switch will be put. Su being the case, a systematic study of the response curv of many switches may be undertaken to determine whi is the most suitable for a given application. So far, on the case for the response levels on opposite sides of t point of inflection has been discussed. Because of t desire for relatively large output jumps from a swit (a relatively large range of R_2-R_1) this case is the mo practical.

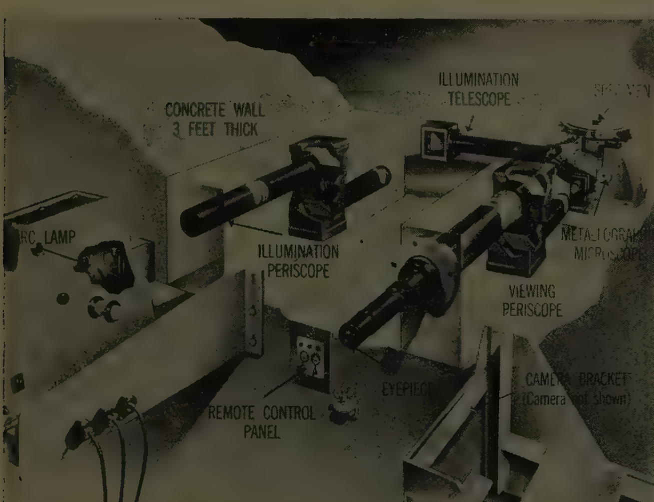
For the sake of completeness, however, it would be w to set down the method for determining the optimum to be used when both points are on the same side of t inflection point. The method of arriving at the criteri will not be discussed, being somewhat trivial. A li through the point furthest from the point of inflection, an tangent to the curve, sets the value of β as before. second line, parallel to the first and also tangent to t curve, is drawn on the other side of the inflection poi The horizontal spacing between these lines and th $R=0$ intercepts are then used as previously, if the seco line has its point of tangency between the two end poin If it does not, the tangent to the curve must be drawn at t point nearest the point of inflection. The cotangent this new line then equals the optimum β. This ca requiring close spacing of R_1 and R_2, is seldom of practic interest.

Ordinary snap-action or toggle switches have respon characterized by a hysteresis curve. As such, they special examples of S curve systems. The hystere generally arises from regenerative feedback in the syst and, conversely, often can be eliminated or optimized the addition of degenerative feedback. In general, shape of the S curve between the transfer points (sho dashed in Figure 4) cannot be determined experimental Under these circumstances, the optimization may eith be carried out on a trial and error basis, or sufficie inverse feedback may first be added to allow an expe mental determination of the single valued curve. If t is done, the previously described analysis may be perform and the β so obtained indicates the amount of inve feedback to be removed from the system.

This procedure and analysis may well find applicati in such separate fields as relay-controlled servomechani and digital computers. An attempt is already under to apply some of the principles to a new method of psyc logical group testing.

Remote-Control Microscope Aids Atomic Scientists

This schematic diagram shows the operation of the remotely controlled microscope made by the American Optical Company's Instrument Division for the Knolls Atomic Power Laboratory which is operated at Schenec-



tady, N. Y., by the General Electric Company for the Atomic Energy Commission. With the aid of this microscope scientists may safely examine highly radioactive metal specimens located inside a test chamber with 3-foot concrete walls. Two periscopes are provided: one to carry in light to the specimen; the other to bring out its magnified image, so it may be examined visually or photographed. The offsets in the periscopes trap harmful radiations.

Power Transformer Noise in Residential Areas

A. V. LAMBERT
ASSOCIATE MEMBER AIEE

HE PROXIMITY OF humming electric equipment to dwellings is becoming a concern to the utility engi-s. The main cause of this noise is the minute pulsation ie laminations submitted to a 60-cycle-per-second alter-ng flux. This phenomenon is called the magnetostric- and its intensity depends on the induction present in the .

lthough the magnetostriction of the cold rolled steel in modern transformers is smaller than that of hot d steel, economics dictates the adoption of higher flux ities, thereby offsetting the magnetostrictive advantages. that reason, the usual approach to transformer noise ction consists of reducing the flux densities. This re- in a larger and thereby more costly transformer, for h the manufacturer will not guarantee a definite noise ction unless he uses hot rolled steel in the construction e core laminations.

an attempt to determine the value of isolating me-nically the core and coil assembly from the tank and of posing a sound barrier between the core and the tank s, a series of tests was performed on a 15-kva distri-on-type transformer. The results indicated that sub-tial improvement could be realized. The same correc-measure applied to a 3,000-kva transformer also showed nprovement, although the manufacturer does not guar-e the same result for all transformers. This improve-t may be attributed to the dampening effect of the oil; effect, however, is questioned by some. While the pening of low frequencies is questionable, the higher encies may be reduced so as to make the transformer d quieter in the distance, as the higher-frequency ds carry further.

e corrective measures that the utility engineer can y are threefold. He can install a quiet transformer, l a sound barrier around the transformer, or isolate the former by building the substation on a large lot. Be-starting to study the problem, however, he must find what the nonobjectionable noise should be at the dwell-nearest to the substation. If this noise is the same as existing before the transformer is installed, there is little ce that complaints will arise, unless it be for esthetic ns or because of radio interference. Thus, the prob-is to find a quick and practical way to compare the before and after the new substation transformer is d in operation.

the present state of the art, two noises can be com-l by their total noise level and their frequency spec-. While the noise level meter is used universally in field measurements, the frequency analyzer is very impractical for such work. However, the various weightings built into the noise level meter make it possible to measure the harmonic index* which gives an indication of the frequencies contained in the noise. The noise level and the harmonic index of the ambient thus can be determined before construction starts. These two quantities, readily obtainable with the noise level meter, can be used as a reference.

To determine the rate of noise level decrease with distance, field measurements were made around an existing substation located far from any building. The average noise level decrease in various vertical planes then was plotted as a function of the distance. Thus, knowing the nonobjectionable noise level, the chart makes it possible to determine either the minimum distance required between the transformer and the first dwelling or for a given distance, the noise level at the transformer. If it is not possible to obtain a transformer with the required noise level, the construction of a sound barrier that will reduce the noise sufficiently is in order.

The two types of sound barriers being built at the present time are the partial barrier and the enclosure, partly roofed or not. Bricks and concrete blocks are the materials most commonly used and the results obtained with these heavy-type sound barriers have been satisfactory. However, if the walls thus built are not covered with a sound-absorbing material, the noise can be built up inside the enclosure or reflected in an opposite direction. As a consequence, the ventilation openings provided in the walls of the enclosure have to be closed or this condition may cause another noise problem to arise.

A lighter type of sound barrier built with resonant cavities may prove to be a satisfactory solution. Briefly, this type of sound-absorbing structure would be composed of a perforated front panel and a solid impervious back panel, separated by an air space. The dimensions of these perforations, their spacing, the thickness of the front panel, and the air space between the front and the back panels are all variables that determine the frequency of resonance of the air space for which the sound absorption is maximum. Such structures thus could be designed to work as acoustical filters for specific frequencies, since the predominant frequencies of power transformers can be accurately determined.

Economics will determine the solution to be adopted. By a careful study prior to the construction of a substation, the utility engineer can be more definite in his specifications for such installations, thereby eliminating the possibility of subsequent difficulties arising in the future because of a noisy transformer.

of paper 51-299, "Audio Noise of Power Transformers in Residential Areas," nended by the AIEE Committee on Transformers and approved by the AIEE cal Program Committee for presentation at the AIEE Pacific General Meeting, d, Oreg., August 20–23, 1951. Scheduled for publication in AIEE *Transactions,* 70, 1951.

Lambert is with the Portland General Electric Company, Portland, Oreg.

* Harmonic index is defined as the difference between the noise level measured by the "flat" response and the noise level measured by the 40-decibel response curve: $hi = db_{\text{flat}} - db_{40}$.

INSTITUTE ACTIVITIE

Number of Technical Sessions Increased to 73 for 1952 Winter General Meeting

The number of technical sessions and conferences for the Winter General Meeting has been increased from 68, as announced in the November issue of *Electrical Engineering*, to 73. Among those sessions which have been added are: Industrial Control, Space Heating, Management, Electrical Applications in Pipe Line Transportation, Electric Heating, Industrial Power Systems, Electronics in Industry, and Feedback Control Systems.

As has been the custom for the past three years, the Hotel Statler in New York City will again be host to the members for the meeting to be held from January 21 through January 25. When the final program is announced, it is expected that the maximum facilities of the Hotel Statler will be in use.

Future AIEE Meetings

AIEE Conference on Feedback Control Systems
Haddon Hall Hotel, Atlantic City, N. J.
December 6–7, 1951

Joint AIEE-IRE Computer Conference
Benjamin Franklin Hotel, Philadelphia, Pa.
December 10–12, 1951

AIEE Conference on Electronic Instrumentation in Nucleonics and Medicine
(*page 1116*)
Hotel Commodore, New York, N. Y.
January 7–8, 1952

Winter General Meeting (*page 1106*)
Hotel Statler, New York, N. Y.
January 21–25, 1952
(*Final date for submitting papers—closed*)

South West District Meeting
Jefferson Hotel, St. Louis, Mo.
April 15–17, 1952
(*Final date for submitting papers—January 16*)

North Eastern District Meeting
Binghamton, N. Y.
April 30–May 2, 1952
(*Final date for submitting papers—January 31*)

AIEE Conference on Electronic Converter Applications and Tubes
William Penn Hotel, Pittsburgh, Pa.
May 5–6, 1952

Summer General Meeting
Hotel Nicollet, Minneapolis, Minn.
June 23–27, 1952
(*Final date for submitting papers—March 25*)

Pacific General Meeting
Phoenix, Ariz.
August 19–22, 1952
(*Final date for submitting papers—May 21*)

INSPECTION TRIPS

The Inspection Trip Committee is proceeding with final arrangements for a variety of inspection trips of technical and general interest. Among these trips are the following:

1. Sewaren Generation Station of the Public Service Electric and Gas Company, Sewaren, N. J.
2. Bell Telephone Laboratories, Murray Hill, N. J.
3. Steinway Piano Company, New York, N. Y.
4. Port of New York Authority Bus Terminal, New York, N. Y.
5. Radio City Music Hall, New York, N. Y.
6. Metropolitan Museum of Art (Special Lighting Exhibit), New York, N. Y.
7. New York Curb Exchange, New York, N. Y.
8. Manufacturing and Repair Division—Westinghouse Electric Corporation, Hillsdale, N. J.
9. United States Signal Corps Photographic Center, New York, N. Y.

Details of these trips and others will be forthcoming in the January issue of *Electrical Engineering*.

THEATER TICKETS

It is expected that tickets for the following shows will be available to out-of-town AIEE members during the week of the meeting.

Prices listed are for orchestra seats Monday, January 21, through Thursday, January 24, evenings:

A Tree Grows In Brooklyn	\$7.20
Affairs of State	4.80
Call Me Madam	7.20
Guys and Dolls	6.60
Seventeen	6.00
South Pacific	6.00
The King and I	8.40*
Two on the Aisle	6.00

*These tickets are not available to us from the box office and must be obtained through brokers. The price shown includes broker's fee. It may become necessary to classify additional shows in this category.

Requests should include checks payable to "American Institute of Electrical Engineers," first and second choice of both name and date of show, and should be sent to Theater Ticket Committee, AIEE Headquarters, 33 West 39th Street, New York 18, N. Y. Preference will be given to requests for seats in blocks of pairs and the committee reserves the right to reduce requests to sellout shows to two tickets and will refund all money which may be received for unsatisfied requests.

HOTEL RESERVATIONS

Blocks of rooms have been set aside at the Hotel Statler (meeting headquarters) and nearby hotels for members and gu attending. To be sure of hotel accomm tions, reservations should be made p to January 10, and sent directly to hotel of choice, and to only one h Mention AIEE in your request and sen copy to Mr. W. G. Vieth, Vice-Chairm Hotel Accommodations Committee, Western Union Telegraph Company, Hudson Street, New York 13, N. Y. second and third choice should be noted this copy. If the accommodations are available at the hotel requested, the H Accommodations Committee will tra the request to one of the other hotels.

Hotel rooms have been reserved at following hotels, and all rates are sub to a 5 per cent New York City hotel room

Hotel Statler (meeting headquarters)
7th Avenue, 32nd to 33rd Streets

Single room with bath	\$ 5.00 to \$
Double room, double bed	8.00 to 1
Double room, twin beds	9.00 to 1
Parlor suites	22.00 to 2

Hotel Governor Clinton, 7th Avenue at 31st Street

Single room with bath	\$ 5.00 to \$
Double room, double bed	8.00 to
Double room, twin beds	9.00 to

Hotel McAlpin, Broadway and 34th Street

Single room with bath	\$ 5.00 to \$
Double room, double bed	8.00 to
Double room, twin beds	9.00 to

Hotel New Yorker, 34th Street and 8th Avenue

Single room, tub and shower	\$ 5.00 to \$
Double room, double bed	8.00 to
Double room, twin beds	9.50 to

Hotel Martinique, Broadway and 32nd Street

Single room with bath	\$ 4.00 to \$
Double room, double bed	6.50 to
Double room, twin beds	7.50 to

Hotel Commodore, 42nd Street at Lexington Avenue

Single room with bath	\$ 5.50 to \$
Double room, double bed	9.00 to
Double room, twin beds	10.00 to

Hotel Roosevelt, Madison Avenue at 45th Street

Single room with bath	\$ 6.50 to \$
Double room, double bed	12.50 to
Double room, twin beds	13.50 to

DINNER-DANCE

The dinner-dance promises to be the outstanding social event for the conve delegates and their ladies. It will be Thursday, January 24, in the main ball of the Hotel Statler. Formal dress i quested. Music and general arrange will be the same as those which prov enjoyable last year. Begin to plan for table of ten for this popular event of the W General Meeting social activities. Res tions at \$12.00 per plate will be accepte the Dinner-Dance Committee, AIEE H quarters, 33 West 39th Street, New Yo N. Y. Checks should be made payab "Special Account, Secretary, AIEE." committee is under the chairmansh J. G. Derse.

SMOKER

The Smoker Committee, under the manship of D. M. Quick, announce the Smoker will be held at the Hotel

ore on Tuesday evening, January 22. rvations should be sent to the Smoker mittee, AIEE Headquarters, 33 West Street, New York 18, N. Y., at an date. Tables for ten persons will be able and the price of tickets will be) per person. Checks should be made ble to "Special Account, Secretary, E." Reservations received after January ll not be honored.

LADIES' ENTERTAINMENT

ne Ladies' Entertainment Committee, r the chairmanship of Mrs. R. F. ver, is planning a program of unusual est for the ladies. On Monday, ary 21, there will be the usual "Get uainted" Tea at the Ladies' Head-ters in the Statler. On Thursday noon there will be a luncheon and fashion show at Sherry's. A trip to Idlewild International Airport also is being planned for the ladies.

WINTER GENERAL MEETING COMMITTEE

The members of the 1952 Winter General Meeting Committee are: G. J. Lowell, *Chairman;* C. T. Hatcher, *Vice-Chairman;* J. J. Anderson, *Secretary;* W. J. Barrett, *Budget Co-ordinator;* C. S. Purnell, *Vice-President, District 3, AIEE;* M. M. Brandon, *Technical Program;* J. P. Neubauer, D. W. Taylor, J. D. Tebo, D. T. Braymer, *General Session;* R. T. Weil, *Monitors;* G. T. Minasian, J. B. Harris, Jr., *Publicity;* C. N. Metcalf, *Hotel Accommodations;* E. R. Thomas, *Registration;* D. M. Quick, *Smoker;* Mrs. R. F. Brower, *Ladies' Entertainment;* J. G. Derse, *Dinner-Dance;* F. P. Josslon, *Inspection Trips;* J. G. Aldworth, *Theater-Radio.*

AIEE President McMillan is addressing those attending the Fall General Meeting during the General Session

K. Glennan Is Principal Speaker at Fall General Meeting Which 1,700 Attend

ne Cleveland Section was host to the General Meeting which was held in eland with headquarters at the Hotel eland, October 22–26, 1951. In 37 ons 151 technical and conference papers presented, many of which were par-arly appropriate to the industrial center leveland. On the business side, an all-meeting of the Board of Directors was on Thursday, which was followed by rum of the Technical Committee Chair-in the evening (story below). During essions 35 meetings of committees and ommittees were held. Other features a General Session on Tuesday morning, ag smoker, dinner-dance, a special ram for the ladies, and inspection trips cal industrial plants. A total of 1,714 bers, guests, and students attended the ing.

GENERAL SESSION

ne General Session on Tuesday morning presided over by D. E. Moat, Chairman ne Fall General Meeting Committee. introducing the committee personnel e efforts made this meeting such a ss, he introduced Mayor Thomas E. e of Cleveland, who welcomed those in dance to the city. He was followed by . Strasbourger, Vice-President of Dis-2, who also welcomed the members to eland and then announced the winners ne prize papers, after remarking that papers had been considered in the petition. First prize was awarded to L. Kershaw for his paper, "Automatic hering to Reduce the Hazard of Aircraft ne Failure at Take-Off" (*EE, Nov '50, 53–58*). Second prize was awarded to B. Kouwenhoven and W. T. Sackett, for their paper, "Contact Resistance—Contribution of Nonuniform Current ."

ne next speaker was AIEE President . McMillan, who told about his recent ities as President when he and AIEE etary H. H. Henline attended the ference of Representatives from the neering Societies of Western Europe the United States at The Hague at the invitation of the Koninklijk Instituut van Ingenieurs, September 17–21, 1951. President McMillan and Secretary Henline were representatives of AIEE and they were accompanied by W. N. Carey and C. E. Davies, secretaries of the American Society of Civil Engineers and The American Society of Mechanical Engineers respectively.

After outlining some of the main topics which were discussed at the conference (see the report of the conference on page 1123), President McMillan gave his impressions of the countries he visited. In Oslo, Norway, he inspected engineering schools and generating plants. In both Oslo and Stockholm he found that every effort was being made to relieve the coal situation by expanding the use of hydroelectric plants under state aid. President McMillan was the guest of honor at a dinner given him by Swedish engineers in Stockholm. He admired the progress that Norwegian engineers have been making in aiding their country's recovery program in effect since the ending of World War II. After visiting Denmark, he went to Switzerland, where hydroelectric systems also are expanding, and from there he went to France, whose testing system for their electric utilities he greatly admired. While in London, he attended the installation of officers of The Institution of Electrical Engineers.

The main address of the session was given by Dr. T. Keith Glennan of the Atomic Energy Commission, whose fine talk, "Your Stake in Atomic Energy," was received enthusiastically by the members. (For the complete text of this address, see pages 1033–38.)

Technical Committee Chairmen Forum Considers Public Relations, Conference Papers, and Divisional Organization

The fourth Forum of Technical Committee Chairmen was held on Thursday evening, October 25, with L. F. Hickernell, Chairman of the Technical Advisory Committee, presiding. Among the topics discussed were ways in which to make conference papers available, Divisional organization, and public relations.

President F. O. McMillan, Honorary Chairman, opened the meeting and explained that the purpose of the forums was to provide a place to discuss and thrash out certain problems of current common interest without an attempt to legislate on matters.

CONFERENCE PAPERS

In respect to the availability of conference papers, Chairman Hickernell drew attention to the motion passed at the last forum which recommended that the present system be continued and that the authors be asked to bring several hundred copies of their papers to the meetings for sale by the Institute.

K. B. McEachron, Chairman of the Publication Committee, explained that the Publication Committee had given considerable time and thought to the recommendation to charge for copies of conference papers furnished by authors but this did not seem to be the wise thing to do. The Publication Committee decided to explore the matter further and to prepare a questionnaire for distribution to the authors of all conference papers on the program of the Fall and Winter General Meetings. Replies received from 25 authors on the first two days of the program of the Fall General Meeting indicated that 23 had brought manuscripts to the meeting, 18 had brought duplicate copies in quantities ranging from 20 to 200, and 22 said that they would be willing to furnish 50 duplicate copies for distribution on another occasion. Twenty-two out of the 25 also expressed the willingness to furnish original copies in standard form for reproduction. Fifteen authors could have made their papers available 3

to 30 days in advance of the meeting, two in 31 to 60 days, and five in 61 to 120 days in advance. The committee would have more data later but the replies so far received indicated that a reasonable solution to the conference paper problem was at hand.

In discussion, the question was raised as to whether it was the intent to have the conference papers made available in advance of the meetings so the discussion could be preserved. In reply to this question, Dr. McEachron advised that it was not the intent to make the conference papers available in advance of the meetings, and after presentation if the author is asked to revise his paper he is no longer interested in the matter and experience has proven an unwillingness to furnish reproducible copy. However, headquarters might take back copies from the meetings and distribute them for a period of a month or six weeks after the meeting and any oversupply would be returned to the authors. The view was expressed by J. E. Clem that many conference papers were presented because the authors did not wish to disclose the contents of their contributions three months in advance and since that was the case the authors should be required to furnish duplicate copies of the papers at their own expense in sufficient time so that discussion could be obtained. The procedure would not be practical, however, as there was no control over the conference papers.

Others reported that the Association of Iron and Steel Engineers and the Pennsylvania Electric Association have been requesting authors for some time to furnish copies of their papers for distribution. The Chairman of the Air Transportation Committee, D. E. Fritz, reported that at a recent conference in Los Angeles 23 authors out of 26 papers on the program made copies of their papers available and F. D. Snyder of the Textile Industry Subcommittee advised that in this field quite a few authors did not have facilities for making copies of their papers available and the subcommittee undertook the project. Authors with large companies do not have the problem where the company foots the bill but individuals have considerable difficulty where an outlay of \$30 or \$40 might be required. Still another suggestion was made to the effect that authors should supply the chairmen of committees with 20 copies of their papers so that they might be distributed for discussion. The suggestion was made by B. J. A. Skrotzki that in order to prevent a wasteful distribution all authors of conference papers should be required to submit their papers to the Papers Desk so that they could be distributed one to a person.

In conclusion, Dr. McEachron appealed to the presiding officers of technical sessions to see that the questionnaires are answered by the authors of all conference papers.

DIVISIONAL ORGANIZATION

To introduce the subject, M. D. Hooven, Chairman of the Planning and Co-ordination Committee, explained that he had sent a letter on October 2 to past, present, and future committee chairmen to obtain views on how best to formalize and codify Divisional operation under the expanded technical committee organization. The letter stemmed from the discussion at the Toronto forum. The replies indicated that there was unanimity in certain areas and varying views in others.

Practically everyone favored Divisional operation. With respect to election versus Presidential appointment of committees there was general agreement that the present method of recommending the personnel to the President for appointment by him satisfied the democratic process. As the functions of the Technical Program Committee and the Technical Advisory Committee were both administrative, one arranging programs and papers, the other the scopes of technical committees, there was strong opinion that these two committees should be combined as a top committee. Some suggestions were received to the effect that the liaison or representation between the Board of Directors and the technical committees should be strengthened but this subject was not explored fully.

In discussion of the matter, there was general agreement that a top level committee should be established but in respect to how this committee might be tied in with the general committees of the Institute most technical committee chairmen were not in a position to give advice. As to whether the Planning and Co-ordination Committee also should be considered in the structure, Chairman Hooven corrected a misimpression by explaining that this committee was not a link between the technical divisions and the Board of Directors but a staff committee with problems usually assigned to it by the Board of Directors. A. E. Knowlton of the Planning and Co-ordination Committee raised the question, with respect toward splitting-up in divisions as to whether this was in the best interest to preserve the unity of the Institute.

After much deliberation, the forum passed a motion to recommend to combine or to consolidate into one committee the functions and scopes of the Technical Program Committee and the Technical Advisory Committee. The forum also unanimously passed a motion to recommend its continuation which is to be included in the codification proposed.

PUBLIC RELATIONS

Ways of obtaining good publicity were discussed by G. T. Minasian, Chairman of the Public Relations Committee. In general, engineers, and particularly electrical engineers, are not good publicity people. However, if there were any material which would be of value to the public, general engineers, and electrical engineers, there is a story to be told.

The view was expressed that it would be difficult to train engineers to do a good public relations job but professional people could be hired. With the aid of the publicity kit progress in local sections had been made and on one list there were as many as 5[illegible] people who had been appointed to handle publicity in the local sections. Mr. Minasian suggested that each technical committee might appoint one of their representatives who was publicity-minded to be on the lookout for material of public relations value and professional help would get directly in touch with them in the early stages when sessions were planned and the papers first submitted.

151 Technical and Conference Papers Presented at Fall General Meeting in Cleveland

Symposium on Polyethylene. Polyethylene was the subject of an all-day symposium on the first day of the meeting. Nine papers were presented in all, and these covered the physical and electrical properties of the material and how it is used for various applications. R. A. Schatzel, Rome Cable Corporation, presided over the meeting and some interesting discussions took place in which representatives from some of the leading wire and cable companies as well as users of the cables took part. The chief purpose of the symposium was to give a complete review of what has been done so far in the manufacture and use of polyethylene with a view toward establishing industry standards for this material eventually.

The first paper, "Polyethylene—Mechanical and Physical Properties," by A. E. Maibauer and N. R. Smith, Union Carbide and Carbon Corporation, provided some informative background material on the nature of this plastic. Compared with other plastics such as the phenolics, rubbers, and vinyl compounds, the polyethylene compounds are relatively independent of modifying agents. Polyethylene is made from only one ingredient—ethylene gas—which is made to react with itself to form polymers consisting of a relatively large number of ethylene units. By controlling reaction conditions, molecular weights ranging from about 1,000 to 38,000 can be produced. Stress-strain data and weathering data for the material were presented, and in connection with the latter it was pointed out that about 2 per cent carbon finely dispersed through the material improves its weathering characteristics greatly. Some of the important factors to be considered in selecting the proper grade of polyethylene for a particular application also were discussed.

"Fabrication, Specifications, and Applications for Polyethylene," by W. J. Canava[illegible] and N. R. Smith, Union Carbide and Carbon Corporation, was the second paper in the series and discussed the techniques used in the fabrication of polyethylene by extrusion, molding, calendering, and coating. Specifications for high-frequency dielectrics, colored dielectrics, and grades suitable for outdoor exposure were presented; and some of the more important applications for polyethylene were reviewed. Extrusion is the most widely used process for fabricating the material. This is done by forcing the heat-softened material through a die by means of an Archimedean screw rotating in a horizontal cylinder. Good temperature control is highly important to this process as is also the proper design of the die. The chief use for polyethylene at present is as an insulating and jacketing material for wires and cables. In this respect, its properties make it useful for high-frequency applications such as coaxial cable as well as high-voltage cables and uses where exposure [illegible]

er, chemicals, or corrosive conditions be encountered.

. J. Warner, Federal Telephone and lio Corporation, presented a paper tled "Physical and Electrical Characstics of Polyethylene as Influenced by nperature and Electrical Stress." Mr. rner pointed out that polyethylene was l as a dielectric to replace gutta percha ubmarine cables as early as 1938, and t its excellent high-frequency characstics were first noted in 1939. He also cribed briefly some equipment developed neasure resistivities of the order of 10^{21} n-centimeters, which was needed to ke measurements on polyethylene. One he important limitations of this insulating terial is corona loss between the copper l the insulation and within the insulation terial itself. This problem seems to be ectly related to the fact that the polyylene contains up to 10 per cent volume dissolved air. The dielectric strength of material would be increased greatly if air could be eliminated.

he use of polyethylene in telephone lications was described by Victor Wall-, Bell Telephone Laboratories, in a er entitled "Polyethylene for Wire and ble." For such application, the cables st have a service life of at least 20 years. ginally, service life was found to be very r, when exposed to weathering, with cks appearing within 6 months' time. Wallder described some equipment l for accelerated weathering tests. This sisted of a carbon arc and water sprays ted in a tank in which wire and cable imens were hung. It also was found crack resistance is related to the molec- weight of the base resins.

he afternoon session of the symposium devoted to applications of polyethylene various fields. M. A. Lipton, United es Signal Corps Engineering Labora- s, gave an evaluation of polyethylene use in field wire and cable. His report particularly timely, as he had just rned from a trip to the Korean battle- t where he inspected polyethylene- red wires and cables used under battle litions, which is the ultimate test for military equipment. He also described fly some of the rigid laboratory tests h the wire must undergo to receive al Corps approval.

. A. Del Mar and E. J. Merrell, Phelps ge Copper Products Corporation, pre- d a paper entitled "Polyethylene for er Cables," in which they divided the ible uses of polyethylene in power wires cables under three headings: those no appreciable electrical stress; those alternating electrical stress; and with direct electrical stress. It was ted out that one must be particularly ful in using a new material to take full ntage of its good characteristics and l its weaknesses, and not to treat it more familiar materials. In this con- ion it was hinted that some radically cable designs might result from the use is material.

wo papers discussed the use of poly- lene-insulated cable in power and rol applications. P. J. Croft, Canada and Cable Company, disclosed a ber of experimental applications being d in England and Canada, paying cular attention to techniques for splicing and terminating these cables. J. M. Geiger and C. T. Nicholson, Niagara Mohawk Power Corporation, described the use of polyethylene wire for overhead and underground street lighting, and also its use for control cables in a new power-generating station at Dunkirk, N. Y., where about 750,000 conductor feet of control cable were installed.

"Polyethylene-Insulated Communication Cable" was the title of a paper by H. F. Wilson, A. L. Meyers, and R. C. Mildner, Telegraph Construction and Maintenance Company (London, England). In this paper it was pointed out that besides providing excellent electrical characteristics, polyethylene makes possible a much lower cost wire. Its reduced weight saves time and personnel in installation of overhead lines, and its maintenance costs are low.

Members of the 1951 Fall General Meeting Committee, who helped to make this meeting so successful, are: (seated) V. A. Diggs, C. W. Fick, Mrs. F. E. Harrell, Mrs. V. A. Diggs, D. E. Moat, C. A. Mann; (standing) J. C. Strasbourger, W. R. Hough, F. E. Harrell, R. L. Oetting, J. D. Leitch, C. J. Beller, O. N. Jones, and G. R. Canning

Industrial Control Session. Four papers were presented at the session on Monday morning dealing with industrial control, over which J. A. Cortelli, Clark Controller Company, presided. The first paper by G. W. Heumann, General Electric Company, was entitled "High-Voltage A-C Motor Controllers." The controllers considered in this paper were those operating on power systems with nominal voltage ratings of 2,400 or 4,160 volts. Class-*A* controllers with backup protection only would permit an amount of short-circuit energy to flow through the controller. Today's trend is to recognize the necessity of designing high-voltage controllers with high interrupting capacity so that the controller itself interrupts faults between the controller and the motor without damage to the controller and branch circuit. Class-*E* controllers are of two types: both employ the main power contacts of the controller for starting and stopping the motor but class-*E1* uses these contacts for interrupting short circuits whereas class-*E2* employs fuses for this purpose. The former type has been greatly improved in the last 30 years, especially those contactors which function in air.

L. J. Goldberg, General Electric Company, in his paper, "A New 5,000-Volt Air-Break Contactor for Industrial Service," further described the structure and theory of operation of the air contactors referred to by the previous speaker.

The next speaker, T. H. Bloodworth, Allis-Chalmers Manufacturing Company, presented "High-Voltage Air Break Controllers," discussing the relative merits of air and oil contactors, and giving a detailed description of the action of arcs in different forms of runners and chutes with their advantages and disadvantages.

The final paper of the session, "Low-Current Interruptions of High-Voltage Air-Break Contactors," was given by C. A. Lister, Electric Controller and Manufacturing Company. Factors affecting low-current interruptions of circuit breakers were explained and then the results of tests; these showed that with power factors below 1, the interrupting time with arc transfers was between 7 and 9 cycles and without arc transfers, the time was between 1/4 and 1 cycle.

It was brought out in the ensuing discussion that interrupting low-current circuits, such as that of a running motor, are interrupted easily with a time of 1/2 cycle or less and that more manufacturers should stress high-current contactors' interruptions. The d-c components also should be taken into consideration as well as the contactor tips.

The opening paper of the Monday afternoon session on industrial control was given by R. C. Thompson, Electric Machinery and Manufacturing Company, its title being "Synchronous Motor Control Design." After describing the various steps which a synchronous motor follows in starting and the operation of the field application system, Mr. Thompson discussed undervoltage protection and the difference between it and undervoltage release. Dynamic braking then was discussed and Mr. Thompson showed that simplicity of design and safety of controllers could be furthered if there were greater exchange of information between the users of the equipment and the designer.

"The Selection of Field Circuit Resistance for Synchronous Motors" was presented by W. A. Thomas, Case Institute of Technology, and O. D. Whitwell, The Clark Controller Company, and read by the latter. The first portion of this paper contained a brief description of the methods now used by

synchronous motor designers to control the starting performance and select the field discharge resistance. The authors then proposed a system whereby the designer or user of a synchronous motor could change the starting performance through selection of the proper field circuit resistance.

The final paper of the session was given by C. E. Robinson and A. P. Di Vincenzo, Reliance Electric and Engineering Company, and was entitled "Adjustable Speed D-C Drives for Deep-Draw Presses;" it was presented by Mr. Di Vincenzo. The first part of the paper was devoted to a description of the shearing, shallow, and deep-draw pressures. This was followed by a description of the 500-horsepower d-c motor for driving a 1,000-ton press and the various operating characteristics which have been found from this installation.

System Engineering Sessions. A well-rounded symposium organized by the Subcommittee on System Economics, with C. W. Watchorn of the System Engineering Committee as chairman, presented the basic factors involved in the economic comparison of alternative facilities. A series of five papers dealt with investment costs, annual carrying charges, annual operating and maintenance costs, evaluation of energy differences, and the time cost of money. A sixth major area of this subject will deal with the evaluation of capacity differences and this will be presented at the Winter General Meeting.

The morning session was introduced with an address on "The Growth of the Power Industry in the U. S. A." by E. L. Lindseth, President, Cleveland Electric Illuminating Company. Mr. Lindseth stressed the importance of activities at the present time in view of the extremely rapid growth of the power industry and the national emergency. He pointed out that if the power industry grows in the next 30 years as much as it has in the past 30 years there would be a sixfold increase in generating capacity, about $150,000,000,000 investment in property and plants, and residential customers would increase about fivefold. By all odds, the power industry would be the largest industry in America. This phenomenal growth would take more engineers and more skill, particularly in the executive and management end of the business, which is very significant because there already is a shortage of engineers. He pointed out that technical skill and executive skill are two different requirements and that technical engineering training does not assure management competence but rather seems to mitigate it. He raised the question as to how many engineers today are meeting this challenge and training themselves to develop management competence. In conclusion, he pointed out that the first need today is for general and executive managers and that in the years to come the need for this competence will increase five- or tenfold from what it is at present.

The symposium was organized to investigate the feasibility of generally standardizing sound methods of making economic comparisons. The need for such standardizing is demonstrated by the marked divergence of methods found in the literature. One of management's most difficult problems is making the decisions between alternative proposals for plant installation. For example, should the next turbogenerator be of maximum efficiency obtainable or is the greater fuel consumption of a slightly less efficient unit offset by its substantially lower first cost? The sole objective of economic comparison is to supply estimates of the "upkeep" of alternative facilities—the comparative effect of alternative plans on future revenue requirements.

The first step in such problems is ordinarily an estimate of the capital investment involved and this was brought out in a conference paper entitled "Investment Costs for Use in Economic Comparison of Alternate Facilities" by F. L. Lawton of the Aluminum Laboratories, Ltd. The second step, the upkeep, associated with each proposal is conveniently estimated as an average annual percentage of the capital investment or "first cost." Four major categories of these annual costs are as follows:

1. The annual carrying charges returned on the investment, depreciation, taxes, and insurance, and the nature of such costs together with appropriate methods of estimating them, were presented in a paper by P. H. Jeynes, of the Public Service Electric and Gas Company, entitled "Annual Carrying Charges in Economic Comparisons of Alternative Facilities."

2. The costs of operation and maintenance exclusive of generating costs were presented by W. E. Slemmer, Ebasco Services, Inc., in a paper entitled "Operating and Maintenance Costs for Use in the Economic Comparison of Alternative Facilities."

3. Costs of generating the energy (kilowatt-hours) associated with each plant was presented by A. P. Fugill, The Detroit Edison Company, in a paper entitled "Evaluation of Energy Differences in the Economic Comparison of Alternative Facilities."

4. The annual costs of plants required to supply the power (kilowatts) associated with each plan is to be the subject of a future paper to be presented at the Winter General Meeting under the title of "Evaluation of Capacity Differences in the Economic Comparison of Alternative Facilities."

The arithmetic of economic comparison is just as definitive and rigorous as Ohm's law. It is difficult to anticipate future rates of return, average life of equipment, tax rates, and fuel costs, just as it is difficult to estimate future loads, load factors, and power factor. Once the necessary estimates have been made, there is no question with respect to the proper arithmetical development of the cost comparison. Up to the present, literature has not provided an authoritative method of economic analysis and the Institute was fortunate in having one who is an engineer and also an accountant make the first effort. This was a paper by P. H. Jeynes entitled "Present Worth, or the Time Cost of Money, as a Factor in the Economic Comparison of Alternatives."

R. D. Goodrich, Jr., United States Bureau of Reclamation, presented a paper on a universal power circle diagram. Professor E. T. B. Gross said that the diagrams in this paper represented a great step forward compared to circle diagrams of 30 years ago. They were also considered an improvement from an academic point of view and the method has enabled evaluation of losses very quickly and accurately.

The last paper, by W. E. Enns of Portlan[d] General Electric Company, presented b[y] title only, was on a simple new resistan[ce] type a-c load flow board.

Among the several discussions, freque[nt] reference was made to an article on "Cond[i]tions Controlling the Economic Selectio[n] of Prime Movers" by B. G. A. Skrotzk[i] AIEE *Transactions*, volume 63, 1944, pag[es] 1099–1108. M. J. Steinberg explain[ed] that the Skrotzki paper was fundament[al] and academic and that it was impossib[le] to take into account all of the variables [as] the field was very broad. P. H. Jeyn[es] suggested disregarding Mr. Steinberg's r[e]mark that the paper was academic an[d] pointed out that the equations were ve[ry] practical. E. E. George drew attention [to] the value of setting up estimates so that th[ey] might readily be compared with constructio[n] costs. E. L. Michelson pointed out th[at] the time comes when one must take in[to] account the long-range development of [a] system which involves many factors includi[ng] the reliability. In discussing the evaluatio[n] of energy differences, G. D. Floyd of t[he] Hydro-Electric Power Commission of O[n]tario brought out that the methods to [be] used for hydro plants would have to [be] different from those for thermal plan[ts]. W. R. Brownlee raised the question [of] procedure in the case where a site wou[ld] not be purchased until ten years hence.

Several discussers urged that a committ[ee] or working group should further ampl[ify] and integrate the ideas expressed in t[he] papers with a view toward standardiz[ing] sound methods of making economic co[m]parisons. A. E. Knowlton pointed o[ut] that there are three good reasons for a degr[ee] of standardization. First, investors in [an] enterprise should know that their mon[ey] will be spent as wisely and as advantageou[sly] as possible. Second, the manufactur[ers] should know how the criteria for competit[ive] selection of apparatus and an econor[...] work basis differ from company to compa[ny]. Third, the rate payers and regulat[ory] authorities should have the information [to] obtain uniformity in judgment on the p[art] of the regulated utilities in making expen[di]tures that have to stand the test of pruden[ce]. One or two of the discussions missed [the] point that the symposium was organi[zed] only to investigate the feasibility of gener[ally] standardizing sound methods of mak[ing] economic comparisons and that it h[ad] nothing to do with the subject of r[ate] making. None of the papers relate to r[ate] problems and P. H. Jeynes pointed out t[hat] the failure to distinguish between accepta[ble] rate procedures and factual cost behav[ior] has been recognized as a major source [of] error in making economic comparisons.

Conference on the Selection of Circuit [and] Lamp Designs to Conserve Critical Materi[als]. E. H. Salter, Electrical Testing Labo[ra]tories, was chairman of the session at wh[ich] three conference papers were presen[ted]. The first paper, "Lamps and Auxilia[ries] for Material Conservation and Econom[ical] Lighting," was presented by J. H. Camp[bell] and E. A. Lindsay of the General Elec[tric] Company. Recommended practices as [to] illumination levels in industrial ligh[ting] were reviewed and the increases in both f[oot]candle levels and in watts per square [foot] of lighted areas to produce these levels w[ere] discussed. The consideration of in[...]

ent, high-intensity mercury and fluo-ent lamp-operating requirements led to conclusion that economies can be cted through analyses of lamps, lamp uits, and supply system variables. Com-sons were made on the basis of copper kilovolt-ampere for equal illumination ls. Marked conservation of critical erials was indicated through the use of her voltage or higher frequency supply ems.

Electric Distribution and Control for hting Systems" was the subject of the er presented by R. N. Bell and W. H. ler, Westinghouse Electric Corporation. dern trends were analyzed in power ribution and control for lighting loads industrial installations and consideration given to lighting with incandescent, h-intensity mercury and fluorescent lamps well as to the various means of distribution, ching, and control. Five system ar-gements were investigated and compared the basis of relative cost and copper tent. It was indicated that the invest-nt in distribution system for supplying ting loads can be reduced considerably installing a combined power and lighting angement in which the lights are supplied ectly from the 460-volt supply to the ting load.

ohn Bos, of John Bos and Associates, d "Economics, Operating, and Control perience with 480/277-Volt Lighting tems." He described a typical high-age distribution system for lighting and wed data comparing this with the more al low-voltage distribution system. This lysis showed savings amounting to .00 per kilovolt-ampere for the higher age system, materials conservation of pounds per kilovolt-ampere for copper, 10.4 pounds per kilovolt-ampere for l. The problem of adequate fuse tection for lighting equipment at these ages was discussed.

ession on Insulated Conductors. In a Tues-afternoon session presided over by C. Hatcher, Consolidated Edison Company New York, three papers relating to ulated conductors were presented. The t of these, by Henry Dupre, Burndy gineering Company, was a discussion of ne of the problems involved in the design connectors for aluminum cable which, ause of shortages, is coming into more nmon use. Three important points make design of insulated aluminum cable ferent from that of copper cable: the ct of differential expansion where dis-ilar metals are used; the effect of corro-n where an electrolyte is present; and effects of cold flow of the aluminum. ce these have been considered, the design fittings for aluminum is no more of a blem than for copper.

A. S. Mickley, Philadelphia Electric mpany, gave a paper entitled "Thermal nductivity of Moist Soil," in which he lained the importance of this property soil to electrical engineers calculating ings of underground cables. He pre-ted a theory of thermal conduction in the nposite soil, air, and water based on the umption that the soil can be regarded a unit structure containing a solid mono-of prescribed shape. While this and ne other assumptions are limitations to theory, it is possible to calculate the thermal conductivity of a soil with a reason-able degree of accuracy for most purposes with only the dry density and moisture con-tent known. Mr. Mickley's calculated values agreed remarkably well with measured values.

"Forced-Air Cooling for Station Cables," by E. W. Burrell, A. J. Falcone, and W. J. Roberts, Consolidated Edison Company of New York, described the design and applica-tion of a forced-ventilation system to increase the generator outlet capacity of a modernized station. In this method, air is taken from the outside through filters by a blower which in turn discharges through suitable duct work into a header feeding individual ducts. While such a system generally would not be suitable for new station design, it does, in many cases, offer an economical solution to the problem of eliminating rating limitations existing in cable installations where special restrictions are imposed.

Insulation and A-C Machinery Session. A variety of subject matter was presented in a Tuesday afternoon session of six papers on the subject of insulation and a-c machinery with L. J. Berberich of Westinghouse Electric Corporation presiding. The first paper, by J. S. Johnson of Westinghouse, dealt with basic studies in connection with the nature and method of detection of slot discharge phenomena in high-voltage stator windings. The development of a discharge analyzer and the employment of radio-frequency and audio-frequency methods using a standard noise meter was described. The methods employed involved shutting down the machines and using a testing transformer. The second paper, by J. S. Johnson and Mead Warren of Aluminum Company of America, dealt with the subject of detection of slot discharges in high-voltage stator windings while the machine is in operation. The method employed involved connection of frequency sensitive equipment across all or part of the neutral impedance. The method presented results in test simplifica-tion since it is not necessary to shut the machine down or provide an external source of test voltage. In the discussion, questions were raised in regard to the safety of anyone near the machine and the authors explained that proper safety precautions should be taken by using high-voltage fuses and testing the bars isolated while the machine is running.

In a third paper, D. S. Babb and J. E. Williams of the University of Illinois pre-sented "Network Analysis of A-C Ma-chine Conductors" which showed that the impedance-frequency characteristics of com-plicated conductor and slot shapes can be determined with acceptable accuracy using a relatively simple network. The central network arranged to a model gives a satis-factory general solution much quicker and five hours of calculations are reduced to about $1^1/_2$ hours' time.

Two papers were presented by title only which dealt with the characteristics, per-formance, ratings, and requirements of motors for oil-well pumping units. One of the papers, by J. N. Poore of the General Electric Company, particularly referred to beam pumping of individual wells which constitutes about 90 per cent of the cases where artificial lift is applied. Most of the discussion by B. L. Moore of the Phillips Petroleum Company and C. H. Eckel of the Humble Oil Refining Company centered about the need for higher voltage motors, 440 volts to 2,400 volts, as recommended in a paper by Mr. Halderson, Phillips Petroleum Company, for motors larger than 25 horsepower in order to save in conductor size because the trend is toward the wider spacing of wells.

The last paper was by Sterling Beckwith, Allis-Chalmers Manufacturing Company. It described the design and performance of a 2-pole 3,600-rpm generator capable of supplying a zero time equivalent 3-phase

Lehigh Valley Section Holds Dinner Meeting

Miss Vivien Kellems, Connecticut industrialist who has waged a long fight against the Federal Withholding Tax Law, was guest speaker at the Annual Ladies' Night Dinner Meeting of the AIEE Lehigh Valley Section held in Wilkes-Barre, Pa., on October 12. Miss Kellems is one of eight women members of AIEE. In her talk entitled "Toil, Taxes, and Trouble," Miss Kellems declared that increasing tax levies are contrary to the fundamentals of our Constitution and will lead the country to ruin. In the front row, left to right, are Mrs. S. D. Henry; Mrs. R. D. Evans; Roy E. Morgan; Miss Kellems; R. D. Evans, Wilkes-Barre Division Manager; and Mrs. D. A. Campbell, Jr. Standing: S. D. Henry, Easton Division Manager; J. H. Black, Vice-Chairman; H. E. Charles; W. C. Seymour, Secretary-Treasurer; Mrs. W. C. Seymour; and D. A. Campbell, Jr., Vice-Chairman

short-circuit current of 1,280,000 kva rms symmetrical. The design represents a new departure in large short-circuit testing generators in this country which heretofore had been built with speeds comparable with those of synchronous condensers with salient poles in the order of 10 to 16 poles. The design takes advantage of a principle long recognized that 2-pole machines have inherent reactance which is far below that of machines with salient poles. Low reactance was obtained by using a forged and slotted cylindrical rotor which permits higher peripheral speed and therefore longer pole pitch. High-speed motion pictures of 1,000 to 1,500 frames per second illustrated the relative motion of the stator coil ends under short-circuit tests. The machine has been installed and has been operating satisfactorily for a period of time.

D-C Machinery Session. A session on d-c machinery on Wednesday morning was presided over by Lanier Greer, Reliance Electric and Engineering Company. The first of the three papers, "Standard Temperatures of Reference for Efficiency Calculations," was given by P. L. Alger, General Electric Company. Mr. Alger proposed that the present standard temperature of 75 degrees centigrade used in determining I^2R losses in efficiency calculations of electric machines and transformers is inadequate in view of the marked differences in operating temperature associated with the A, B, and H classes of insulation. He proposed that the standard reference temperatures be revised to 75, 100, and 140 degrees centigrade for typical class-A, class-B, and class-H machines respectively. An alternative method would be to use 20 degrees centigrade plus the guaranteed temperature rise by the resistance or embedded detector method.

A conference paper by W. A. Thomas, Case Institute of Technology, and R. J. Horvat, Auburn Engineering Company, offered a new method for measuring the rotor temperatures of electric machinery. A thermistor is used as the temperature sensitive device. This is imbedded in the windings, and leads are brought out through slip rings to a Wheatstone bridge type measuring circuit. Calibration curves can be obtained for the thermistor by standard methods giving temperature as a function of resistance. Accuracy of better than ± 1 degree centigrade can be obtained because of the large negative temperature coefficient of resistance and because the relatively high resistance of the thermistor reduces circuit error.

A second conference paper, prepared by A. G. Darling and T. M. Linville, General Electric Company, was a report of the Subcommittee on D-C Machinery of the AIEE Committee on Rotating Machinery. The paper was titled "Rate of Rise of Short-Circuit Current of D-C Motors and Generators," and it represents the completion of a project the subcommittee has been carrying on for several years. It deals particularly with fault current analysis and, because the armature current of a d-c machine is alternating, it puts the language of these machines in terms of per unit and cycles.

This paper was, in addition, an effort to summarize previous papers on the subject, but Mr. Linville pointed out that much more work is to be done on transient performance of d-c machines.

Panel on Co-ordinating Safety in Design with Field Operating Conditions.
In his opening remarks to the panel, Hendley Blackmon, Westinghouse Electric Corporation, the chairman of this session held Wednesday morning, spoke about the necessity of keeping the idea of safety foremost in almost any plan of industrial planning. While improvements in country-wide safety measures have reduced the accident occurrence rate to 10 accidents per million man-hours of work and a fire every 8 minutes, even these figures should be reduced. He stressed that the proper design of apparatus is the first line of safety.

C. E. Ganther, Cleveland Electric Illuminating Company, the moderator of the panel, before introducing the members of the panel, said that accidents were due in the main to a wrong combination of equipment, design, and men.

The first panel member, T. H. Cline, Newark Stove Company, spoke about the design of domestic and commercial equipment. Purchasers of electric appliances used in the home expect efficient operation, good looks, and safety. Such devices which are used by anyone must be considered as unlike other apparatus used by trained personnel, and so it must be designed to take rough treatment of all sorts. The design engineer must maintain a balance between manufacturing economy and safety. The importance of laboratory and field testing must not be overlooked.

F. Hamburger, Jr., The Johns Hopkins University, discussed field operations of domestic appliances. He told about an accident caused by an oil burner in an apartment house, which upon a field investigation was found due to ignition delay. There is a great need for better components; for example, polarity plugs providing a positive ground connection by a 3-pole connector.

Edward Luoma, Reliance Electric and Engineering Company, spoke on design of heavy industry apparatus. He discussed the factors influencing the failure of electronic control units. Provision should be made in the control circuit for vacuum-tube failure; the failure of circuit components should be considered, and the quality of these parts and their installation is important. In addition to these factors of circuit component failure, there is the possibility of the failure of the line voltage and, here again, this should be a considered factor. The purchasing agent of a manufacturer should be given a check list showing specifications, tolerances, and so forth, which should be used as a guide when buying parts. He should be given assistance by the sales and field engineers and the three should influence the designer of the products.

H. H. Angel, Bethlehem Steel Company, in his talk about field operation in heavy industry spoke of the need for improved design of industrial apparatus with safety as a predominant factor.

L. G. Smith, Consolidated Gas Electric Light and Power Company of Baltimore, stressed factors of rigid inspection and maintenance of apparatus used by utilities when designed with the ultimate idea of safety. For example, in transformers there is often insufficient working space provided between primary and secondary; circuits are not always properly identified; climbing space is often inadequate, and so forth. He also dealt with the safety factors involved in the arrangement of equipment in generating plants and substations, apparatus used indoors and outdoors because of the design of the equipment in which safety factors had not been sufficiently considered.

W. D. Brown, Duquesne Light Company, spoke from the system operating viewpoint. With the safety of personnel in mind, there should be better correlation between equipment designers and construction men before deciding upon design specifications as there are many small things which should be considered. For example, clearance is needed to check phasing, circuits should be identified, disconnect points are needed, and so forth.

In the discussion following, it was brought out that co-ordinators are needed so that designers of equipment and its users will each understand the other's problems. Mechanical and electrical standards have been set up and safety factors should be incorporated in the standards as well. The question also was raised about what was being done by the engineering profession to make safer installations of equipment in the home. It was brought out that a great many of the hazards of unsafe installations were recognized by engineers, but because of local laws and rulings they were powerless to rectify the conditions, as local politics entered too much in the picture.

An urgent request was made by Mr. Blackmon that anyone with safety problems and ideas for improving safety conditions write to him and that he would bring it to the attention of the Safety Committee.

Session on Power Generation. The various aspects of this important subject were presented Wednesday morning in four conference papers sponsored by the Committee on Power Generation with H. R. Harris of The Detroit Edison Company presiding. The first paper which was presented dealt with "Fire Protection in Electric Stations" by H. A. Bauman and W. E. Rossnagel, Consolidated Edison Company of New York, Inc. This paper appears in full on pages 1040–45 of this issue. The subject is treated from the aspect of prevention through the proper design as well as the equipment for fire fighting and the experiences with several different kinds of fires on the Consolidated Edison System.

The second conference paper presented by W. W. Satterlee of the Westinghouse Electric Corporation dealt with the hazards of fire and explosion and their reduction through developments in transformer design. The author illustrated with colored slides the developments of several types of transformers from the early days up to the present time including several forms of class-B transformers and vapor-cooled transformers in which all the atmosphere inside is noncombustible.

"Relation of Transformer Design to Fire Protection," by E. D. Treanor and L. C. Whitman of the General Electric Company, was presented by Mr. Treanor. The method of approach used by the authors was to test the components of dry-type transformers and the authors analyzed the results of standard American Society for Testing Materials tests and some additional

ts on representative samples of class-*A*, , and -*H* insulation. Conclusions were awn from the results of the tests in respect both the open-type and sealed-type of y transformers.

In the last paper, the theory of water-ray fire protection was given for the st time by K. P. Jones and Dawson Powell the Grinnell Company, Inc. Water ays do not cover the fire but dilute the pors. Motion pictures of extinguishing fferent kinds of fires were shown by both e Grinnell Company and The Detroit lison Company.

Television and Aural Broadcasting Systems ssion. One technical and three conference pers were presented at the session at hich I. J. Kaar, General Electric Company, s chairman. The opening paper, pre-nted by A. F. Giordano, Allen B. Du Mont boratories, Inc., was "Blocking Oscillator esign Considerations in the Television eceiver." (See pages 1050–55 of this issue this paper's complete text.)

R. V. Little, Radio Corporation of nerica (RCA), presented "Systems and uipment for Theater Television." At e present time 25 theaters are equipped th television projection facilities and thin the next few months over 100 more e expected to be so equipped. At the oment there are no established standards, t some will be sought next February when e Federal Communications Commission eets.

After discussing the various methods of ge-screen projection, the speaker de-ibed the RCA system. A Schmitt tical system is employed in conjunction th a 7-inch projection cathode-ray tube, pe *7NP4*. A throw of 62 feet from pro-tor to screen is necessary to fill a 15- by -foot screen, although the present appa-tus can be used in theaters where any ngth throw between 40 and 70 feet is ssible.

"Video Switching Problems" was the bject discussed by John Brush, Allen B. n Mont Laboratories, Inc. He explained w the video switching operator must be le to switch from one scene to another d the methods by which this is performed: ling, lap dissolve, montage, wipe-on, and forth. The switching can be direct or direct but, whichever it is, there should a synchronous control for the switching.

The final paper of the session was given C. J. Hirsch, Hazeltine Electronics rporation, entitled "Recent Advances in lor Television." The speaker described e constant-luminance system for the insmission of color pictures in which the formation on the color subcarrier does not fect the picture brightness; then he cussed the oscillating color sequence, a stem in which a reversal of the color quence permits the eye to cancel out errors color due to misphasing.

Industrial Power Systems Session. On Wed-sday afternoon a session was held in hich five papers on industrial power systems re given. The first of these, "Equivalent ntinuous Current for Groups of Variable ads," by W. K. Boice, General Electric mpany, described a method for calculat- a continuous current value which is uivalent to the load presented by a number independent loads with diverse magnitudes d load patterns. The method is particularly suitable for such loads as resistance welders, arc welders, looms, presses, and elevators, which follow a fairly definite pattern so that an rms current for each load can be evaluated over one typical repetition of the load pattern. The standard deviation (the rms of all random deviations from the average load) is calculated for each load, and from these the total standard deviation is computed. By means of a simple formula, the total standard deviation is combined with the average total current to give the value for equivalent continuous total current.

A paper by W. H. O'Connor, Consolidated Gas Electric Light and Power Company of Baltimore, and H. D. Ruger, Bethlehem Steel Company, described an unusual use of standard relays on the 33-kv tie feeders between a substation of the Baltimore power company and a steel plant. The features of the system are essentially instantaneous differential protection for the feeders even though they are tapped at three intermediate points; overload protection on the basis of emergency carrying capacity of the tie feeders; transfer tripping (because of the possible operation of the steel company's system without a source of zero sequence current); and backup overcurrent protection in case the steel company's main circuit breakers should fail to clear a fault.

The electric power distribution system of the Lewis Flight Propulsion Laboratory of the National Advisory Committee for Aeronautics, located in Cleveland, was described in a conference paper by K. D. Brumbaugh. This laboratory has several large wind tunnels in operation as well as numerous smaller test stands or cells for research on component parts of propulsion systems. The unique nature of this installation presented its designers with a number of unusual electrical problems, not the least of which is demand scheduling, which involves cutting large blocks of power in and out of the system.

Another unusual distribution problem is that of supplying power to the ore loading and unloading dock on the Great Lakes. Some of these systems were described in a conference paper by J. C. Ponstingl, Westinghouse Electric Corporation. In these installations the load consists of many very high peaks which occur when the machines are lifting ore.

Roy H. Whaley, Eli Lilly and Company, described an arrangement whereby his company, a pharmaceutical manufacturer, bought steam from the public utility to generate its own power. The company's generation facilities are paralleled to those of the utility, and the combined operations of the two systems are advantageous to both the industry and the utility. The steam passes through a 1-mile tunnel from the utility to the company, where it drives noncondensing turbines. The steam then is used for heating and for processing in the plant. The advantage of this particular arrangement is that the pharmaceutical manufacturer is free from coal and ash handling, as a high degree of cleanliness must be maintained; and the parallel connection with the utility provides extra insurance against power failure.

Session on Transformers. Seven papers were presented Thursday morning with F. J. Vogel of the Illinois Institute of Technology and Chairman of the Transformer Committee, presiding. J. A. McDonnell and H. E. Crabtree, General Electric Company, presented a paper on the evaluation of butyl insulation for outdoor instrument transformers. The authors concluded that the molded butyl compound has been found applicable to low-voltage (600 volts and below) outdoor instrument transformers which represents an additional advance in the use of this new insulation.

In another paper, S. Bennon of the Westinghouse Electric Corporation gave a practical method of analysis which permits the design of the closed core reactor with engineering accuracy. The paper also indicated the value of a closed iron core reactor as a source of fundamental reactive kilovolt-amperes.

A paper entitled "Overvoltages in Saturable Series Devices" by A. Boyajian and G. Camilli, General Electric Company, was presented by Mr. Boyajian. E. C. Wentz of the Westinghouse Electric Corporation brought out that some previous work of a similar character had been done by himself and Mr. Speight. The authors did not know of this work at the time of doing their work.

Among several reports presented by J. E. Clem for the Transformer Committee, the report on transformer magnetizing current and its effect on relaying and air-switch operation evoked considerable discussion. L. R. Janes of the Public Service Company of Northern Illinois took exception to Part 3 of the report in respect to the use of air switches to interrupt the magnetizing current of a transformer. This part of the report failed to take advantage of the results in a paper entitled "Interrupting Ability of Horn-Gap Switches" by S. E. Andrews, L. R. Janes, and M. A. Andersson, Public Service Company of Northern Illinois, which was presented at the 1950 Summer and Pacific General Meeting in Pasadena and published in AIEE *Transactions*, volume 69, part II, 1950, pages 1016–27. Professor E. T. B. Gross endorsed Mr. Janes' criticism of the report.

Another paper, "Insulation Co-ordination and a New Line of Oil Insulated Potential Transformers" by Mr. Vogel and D. R. Laib, Allis-Chalmers Manufacturing Company, which was presented by title only, was widely discussed. Mr. Camilli believed the design similar to an early one of 1943. He cited other data in a paper by Montsinger and Vogel in 1924, as well as cable experience, to the effect that solid insulation was as satisfactory as well-ventilated insulation if properly processed. The discrepancies between what insulation was required to do and the tests now required were emphasized by Mr. Seeley who suggested that some further action should be taken. Attention was also drawn to work by the Germans in the 1920's by both Mr. Wentz and Professor Gross.

In still another discussion, I. W. Gross called attention to the fact that the paper was not so much one on potential transformers as an entering wedge to reduce tests. He cautioned that transformers had to stand 60-cycle voltages to ground continuously for 30 or 40 years. He cited that European transformer failures were as high as 3 per cent a year and wondered if this was due to lower 60-cycle test voltages.

In the closure, Mr. Vogel stated that the

"oil-poor transformer" was not the real subject but that the insulation was the consideration. He explained that the data by Montsinger and Vogel were now superseded and that ventilation leads to safer and more capable design. With respect to present 60-cycle tests, Mr. Vogel pointed out that they were set up in the days of Steinmetz and Lamme or earlier and the considerations then were unknown. In general even when lightning, switching surges, thermal instability, and corona were not very much understood the use of the tests as design criteria had worked fairly well. They were not always complete as some cases of both types of failure can be found.

Session on Recording and Controlling Instruments. Five papers were given on Thursday morning in a session sponsored by the Committee on Instruments and Measurements and presided over by P. A. Borden, The Bristol Company. A conference paper, "Electronic Recorder with Range and Precision Adequate for the Platinum Resistence Thermometer," was given by A. J. Williams, Jr., Leeds and Northrup Company. This device is a highly precise instrument capable of unattended operation with a precision of 0.001 ohm, which is equivalent to 0.01 degree centigrade. Among the other features of the device are automatic changing and recording of decade resistors, compensation for expansion of the recording chart, and an exceedingly small zero offset of the null detector.

The basic requirements of a d-c null detector were discussed in a paper given by F. L. Maltby, The Bristol Company. In the apparatus described, the error signal is converted to an alternating potential of the power frequency by a reversing synchronous contactor. This voltage is amplified and applied to the control winding of a 2-phase motor which has its reference winding continuously energized at the control frequency. The sensitivity of the detector is largely dependent on the symmetry of the reversing switch, the attenuation of the amplifier of even harmonics of the operating frequency, and accurate phasing of the reversing switch, amplifier, and motor.

A. J. Hornfeck, Bailey Meter Company, gave a conference paper in which he discussed the use of computing circuits and devices for industrial process functions. In such applications, computing circuits often can increase the response speed and range of control devices and instruments. Other advantages are that transducers can be located remotely more easily, and good accuracy can be achieved over a wide range of operation. Generally speaking, analogue computer circuits are most suited for continuous control devices, while digital computers can be used readily in on-off types of controls.

A precision time-proportioning electronic thermostat for temperature control of batch processes or small furnaces was described by F. A. Ransom, National Bureau of Standards. The proportioning feature of the thermostat is achieved by applying a sawtooth voltage to the grid of a control tube. The position of the sawtooth is adjusted with respect to the cutoff voltage of the tube to give the desired proportion. Thus, when the error signal is zero, the sawtooth voltage is centered and the tube conducts 50 per cent of the time. This circuit is capable of high sensitivity and has the added advantage of having no dead zone at the control point.

The fifth paper to be presented in this session was "Liquid Level Alarm Device," by F. O. Wisman and W. E. Windsor, Bendix Aviation Corporation. Developed originally to sound the alarm to the drivers of passenger busses when the liquid level in hydraulic fluid reservoirs went too low, the device uses a thermistor mounted in the side of the tank and connected in series with a battery and alarm device. When the oil level drops so low that the thermistor emerges into air, the rate of cooling changes and the current increases sufficiently to operate the alarm. Because of its simplicity, this device gives an extremely high reliability, which is essential for the type of service for which it was intended.

Session on Radio Communication. Three of the four papers presented at this session were concerned with radio communication and its effect on transportation. The chairman of the session was C. E. Smith, United Broadcasting Company, Cleveland.

The first paper of the session was presented by E. M. Mortensen and C. B. Young, "A Short-Haul Radio Communication Link Channelized by Time Division." (For complete text see pages 1094–99.)

"Radio Aids to Navigation on the Great Lakes" was presented by Commander L. E. Brunner, United States Coast Guard. In considering radio applied to ship navigation, the factor of safety plays an important role: "fail-safe" must be thought of as not imparting erroneous data even though the equipment is operating. The reliability of the data presented electronically must be considered; those which are presented on an oscilloscope are more reliable, for example, than those which are given to the navigator as a meter reading. Data can be sent in two ways: one by which the ship's navigator gains the information from a shore station and evaluates the information himself, as with a ship-borne radio direction finder, and the other in which the shore station derives the information from the vessel and sends it by radiotelephone to the ship's navigator, as data derived from a shore-based radar installation. Ship-borne radar is used not only as a collision-prevention device but also as a navigational aid. Radar reflectors located on the shore are of two types: passive and active. The former type merely reflects the signals back to the ship showing as a directional pip on the scope; the active type is the Ramark, which is essentially a reflector that absorbs some of the signal energy and then, after the initial impulse is reflected, retransmits some of the energy after a fraction of a microsecond, and shows on the scope as a series of dots following the original pip.

F. H. Menagh, Erie Railroad, and Ellis Jones, Federal Telephone and Telegraph Company, presented "VHF Communication as Applied to Railroad Operation." Mr. Menagh described the operational functioning of the equipment on the Erie lines between New York City and Chicago and gave numerous examples of how radio facilities between wayside stations and moving trains and between the locomotive cab and the caboose speeded traffic and also were used as an accident preventive. Mr. Jones described the equipment for both the mobile and immobile 160-megacycle 2-way stations. Although new equipment has been developed and installed since 1946, it has been designed so that it can be employed with the older apparatus.

The last paper of the session was given by R. H. Herrick, Lorain Telephone Company, and W. J. McGerry, Coal and Ore Exchange of Cleveland; it was entitled "Radio Communication Speeds Ore Transfer between Boats and Railroad Cars." Mr. Herrick described the radio equipment at the eight shore stations and those on shipboard. Eight channels in the 2- to 9-megacycle range and six in the 156- to 162-megacycle range are used as well as one safety channel, which is monitored constantly. The sets are designed for operation on 110 volts d-c and any land telephone line can be connected to any of the shipborne radio stations within a minute. Mr. McGerry described the old method of issuing orders: instructions were telegraphed to docks at which the vessels had to stop, thus losing much time. Now instructions are given to the captains of vessels by radiotelephone while the ships are long distances from their destinations and the pertinent data gained sufficiently far in advance have saved much time and money. The speaker estimated that within the past year the Coal and Ore Exchange handled ships carrying more than 130,000,000 tons of commodities and orders were given entirely by radiotelephone.

Filter Design Symposium. Four conference papers were given on Thursday afternoon, with P. F. Ordung of Yale University presiding.

F. Hallenbeck, Bell Telephone Laboratories, gave an evaluation of the methods used and the fields of engineering involved in lumped circuit filter design. He described the latest technique, called the potential analogue method, in which the desired characteristics of a filter are made analogous to the potential distribution of the charges located along a conductor or on the plate of a plane capacitor.

J. G. Linvill, Massachusetts Institute of Technology, presented an approximation method to help simplify the design of filters. Beginning with a function of given complexity, the method is a cut-and-try approach but is combined with systematic thought between trials.

Filters for the higher frequencies were discussed in the remaining two papers of the session. J. J. Karakash, Lehigh University, gave a paper on coaxial line filters, describing the basic types and some of their practical characteristics. M. D. Brill, Bell Telephone Laboratories, talked about the design and the characteristics of rectangular waveguide filters, using for illustration the waveguide filters designed for the Bell System's new coast-to-coast microwave relay network.

Session on Basic Instruments. Two technical and two conference papers were presented at the session covering basic instruments of which J. H. Miller, Weston Electrical Instrument Corporation, was chairman.

The first paper, "A General Purpose Electronic Wattmeter" by D. E. Garrett and F. G. Cole of the General Electric Company, was read by the former. This direct-reading wattmeter is capable of measuring waveforms, such as plate current and plate voltage. The current and voltage

oints must be isolated, but the d-c components of the current must be kept at the put. The full-scale error is 3 per cent.

"A Polyphase Thermal Kva Demand Meter" was presented by A. J. Petzinger, Westinghouse Electric Corporation. Using the polyphase ampere demand meter, which was developed several years ago, as a basis, voltage compensation was added, resulting in a combination polyphase watt-hour and thermal kilovolt-ampere demand meter, which are independent of each other. Ordinarily kilowatt-hours are measured to satisfy the rate requirements; relatively seldom is it necessary to measure kilovolt-ampere hours or kilovar-hours. The elimination of this unnecessary information permits the two desired quantities to be measured by a single device occupying a minimum of space.

S. P. Detwiler of Haller, Raymond and Brown, Inc., presented "Phase-Sensitive-Detector Characteristics." Characteristics of the two basic phase-sensitive-detector circuits have been evolved and their graphical presentation permits circuitry to be designed to meet specific requirements. The circuit resistances and input voltages may be adjusted to enable operation on the desired regions of the characteristics.

The final paper of the session was "Principles of Converter Design for High-Frequency Measurements" by D. A. Alsberg, Bell Telephone Laboratories, Inc. The introduction of frequency converters as a critical transmission element into the active part of a measuring device for complex electrical quantities provides high accuracies over wide bands of frequency and aids substantially in sweep-type measurements. Attention must be paid to noise, overload, and bandwidth effects to obtain optimum results. It was shown that the dynamic range is increased by obtaining low modulation loss, high input capability, and high transconductance in the converter tube. Application of the design principles discussed has resulted in converters operating in the frequency range of 0.05 to 80 megacycles linear to 0.01 decibel and accurate to 0.1 degree over dynamic ranges of as much as 80 decibels.

Cathodic Protection Session. A well-arranged session of five papers dealing with the fundamentals, theory, and practices of several companies and some of the research work in cathodic protection was held Friday morning with L. W. Roush, Carbide and Carbon Chemicals Corporation and Chairman of the Committee on Chemical, Electrochemical, and Electrothermal Applications, presiding. The subject was appropriately introduced by R. B. Mears, Director of Research, United States Steel Company, who gave the first paper on the subject of fundamentals of corrosion.

The second paper treated the cathodic protection of subsurface structures and was presented by D. F. Vanderwater of the Susquehanna Pipeline Company. The importance of the problem was emphasized through realization that it has been estimated that over 60,000,000 tons of steel are in the ground. The speaker, whose company has extensive pipeline systems, gave several specific illustrations of the methods employed in applying cathodic protection to pipelines under different conditions, the degree of protection afforded, and the economic aspects of the problem.

In another paper, the low-energy measurement problems in cathodic protection were presented by H. N. Hayward and R. M. Wainwright of the University of Illinois. The authors used methods diametrically opposed to those usually employed and worked out methods and correction sectors for standard instruments which would permit measurement in the field of "metal-to-soil" potentials with more rugged, less accurate equipment.

Another paper which dealt with marine applications of cathodic protection using graphite anodes was presented by J. P. Oliver of the Union Carbide and Carbon Corporation. The author discussed several different methods of making marine anode installations for the protection of both active and inactive vessels, the sampling of test results, the amount of power required, and the economics of installations. He explained that cathodic protection only recently has been applied to a few small vessels in active service and that excellent results have been reported.

The final paper in the session was presented by W. C. Light of the General Electric Company and dealt with selenium rectifiers as a d-c power source for cathodic protection. The authors were R. J. Stambaugh of the Harco Corporation and L. Burton, General Electric Company. Mr. Light described the characteristics of selenium rectifiers and the construction of complete units which are usually mounted on poles and protected against the sun with special hoods and double-wall casings. The stacks are hermetically sealed for protection against corrosive atmospheres. The stacks are connected in parallel so that one or more of them can be removed and taken to the laboratory while the unit is still in operation under a reduced output.

Magnetic Amplifiers Session. A well-attended session on magnetic amplifiers was held on the last day of the meeting under the chairmanship of E. L. Harder, Westinghouse Electric Corporation. Two of the five papers presented methods for analysis of magnetic amplifiers and their characteristics. One of these, "Predetermination of Control Characteristics of Half-Wave Self-Saturated Magnetic Amplifiers," by Henry Lehmann, General Electric Company, developed a semi-experimental method by which the nonlinearities of the magnetic core can be included in the prediction of magnetic amplifier performance.

L. A. Pipes, University of California, gave a mathematical paper entitled "Steady-State and Transient Analysis of an Idealized Series-Connected Magnetic Amplifier" in which he used the methods of nonlinear mechanics to obtain expressions for the input and output currents in the transient and steady state. He also discussed the problems of time constants associated with the series-connected amplifier.

J. G. Miles, Engineering Research Associates, Inc., briefly discussed his paper, "Bibliography of Magnetic Amplifier Devices and the Saturable Reactor Art," in which is compiled all the known published information and, as Mr. Miles put it, misinformation that has been published on magnetic amplifiers. He also described his method for classifying the material in the bibliography which would make it easier to locate all the material on any particular types of circuits.

A paper, "On the Control of Magnetic Amplifiers," by R. A. Ramey, Naval Research Laboratories, had as its subject some of the many possible control elements that can be used with magnetic amplifiers, such as variable resistances, voltage sources, rectifiers, reactors, thyratrons, and triodes. The use of these elements was illustrated by means of a single-core magnetic amplifier, although they are readily adaptable to more complex circuits.

The final paper of the session, "Magnetic Amplifiers of the Balance Detector Type. Their Basic Principles, Characteristics, and Applications," by W. A. Geyger, United States Naval Ordnance Laboratory, was presented by title only for discussion.

Session on Gas Discharge Tubes and Phenomena. Advances in gas discharge tubes and techniques pertaining to them were covered in a session on the final day of the meeting. D. E. Marshall of the Westinghouse Electric Corporation presided over this session.

The first speaker was M. J. Reddan, who with G. F. Rouse, both of the National Bureau of Standards, presented "Cleanup of Helium Gas in an Arc Discharge." After describing the experimental work which has already been performed on gas cleanup by a number of investigators, the design of the experimental equipment was described from which data were obtained on controlled cleanup resulting from the bombardment of a tantalum surface by positive helium ions. Two types of probe structure were used: one was a wire and the other a cylinder, both being of tantalum. A correction factor was determined by observing the rate of cleanup when the conditions of operation limited the probe current to a negligible value, which rate is referred to as self-cleanup. Probe cleanup occurred at a rate at least ten times as great as that for self-cleanup. The tube was operated with a pulsed negative potential on the probe. The quantity of gas disappearing was calculated from pressure readings made at the beginning and end of a test when all parts of the tube were at room temperature. This was an interim report of the gas cleanup program under way at the Bureau of Standards, whose object is the discovery of information of value to tube designers.

"Basis for Dielectric Tests for Rectifier Equipment" was presented by C. C. Herskind, General Electric Company. A drastic revision of the rules for determining dielectric test voltages was necessitated by the many tube types and rectifier equipment developed together with the growing application of phase control. The test code, *ASA C34.1-1949*, was devised to provide a uniform basis for testing rectifier units embodying a wide variety of tube types, equipment arrangement, and service conditions. The paper dealt with the principal factors considered in formulating the rules for dielectric tests and the general basis for these tests.

H. D. Doolittle, Machlett Laboratories, Inc., presented "The Design of High-Power Vacuum Tubes for Industrial Heating Applications." Analysis of tube failures from industrial applications show three main causes: copper-glass seals do not withstand handling by maintenance personnel; spring-tensioned filament structures are not too reliable; thin-walled copper anodes will not stand occasional overloads. The use of thick kovar metal in glass seals

will withstand about ten times the torsion of the usual copper seals commonly used in transmitting tubes. A self-supporting filament structure not only eliminates the failures caused by filaments sticking in guides and annealing of the spring material but maintains uniform tube characteristics throughout its life. Use of copper anodes from four to eight times thicker than customary permits nearly 100 per cent increase in plate dissipation ratings without additional water flow. For use at normal plate dissipation, the anode temperature runs lower and scaling of the anode with resultant anode puncture is eliminated.

"The Plasmatron, A Continuously Controllable Gas-Discharge Tube" was given by E. O. Johnson and W. M. Webster, both of the Radio Corporation of America. After describing the structure of the Plasmatron, the speaker explained how the plasma, a region of free electrons, is a conducting medium between the cathode and anode and how the plasma's density is modulated. The tube can be used either as a diode or triode and provides better control than the thyratron. When used as a triode, its frequency response is better than when it is connected as a diode, the triode response being fairly flat up to about 10 megacycles.

The final paper of the session, "A Subminiature Voltage Regulator for Microampere Operation," was given by L. R. Landrey, Sylvania Electric Products, Inc. The size of the cathode of this regulator is an important factor in the operation: it was found that the maximum size of the cathode area should be such that it will support the glow covering the cathode; changing the shape of the cathode also affected the regulation. The final design is a double-ended tube, the cathode being connected at one end and the anode to the other end. The nickel of which the cathode is made is the subject of a continuing study as well as a revised formula for gas tubes.

AIEE Electronic Instrumentation Conference to Be Held in N.Y.C.

The Fourth Annual AIEE Conference on Electronic Instrumentation and Nucleonics in Medicine will be held January 7 and 8, 1952. The sessions featuring papers and discussions on the latest developments in instrumentation and techniques in the medical field will be conducted in the Commodore Hotel, New York City.

Prominent among the features of the conference is a special evening meeting at which Dr. V. K. Zworykin and Leslie Flory, of the Radio Corporation of America David Sarnoff Research Center, will present a demonstration lecture on "Television in Medicine and Biology." The audience will see on a television receiver screen what usually is seen through a microscope and in addition they will be shown how ultraviolet light rays are used to great advantage in medical microscopy.

The opening session of the conference on Monday will be devoted to papers on nucleonics in medicine, among them one describing the recently developed therapy device employing cobalt 60. In the afternoon session X rays and gamma rays and their latest uses will be considered. The television demonstration will be preceded on Monday evening by an informal dinner in the hotel.

The application of circuit theory to medicine will occupy the Tuesday morning session, which will be followed in the afternoon with papers on the application of electronic techniques to anesthesia. (A complete program will be published in the next issue.)

The following are the chairmen of the conference committee: *Planning Committee*, J. B. Tebo; *Technical Program Committee*, S. R. Warren, Jr.; *Local Arrangements Committee*, C. L. Shackelford; *Finance Committee*, J. S. Smith; and *Publicity Committee*, G. C. B. Rowe.

Board of Directors Elects New Director and Vice-President

The Board of Directors, on October 25, 1951, took the following actions:

Elected as Director of AIEE for the unexpired term ending July 31, 1954, of A. G. Dewars, deceased: Elgin B. Robertson, president of Elgin B. Robertson, Inc., Dallas, Tex.

Elected as Vice-President of AIEE, representing the Southern District (number 4), for the unexpired term ending July 31, 1953, of John D. Harper, resigned: E. S. Lammers, Jr., Electronics Engineering Supervisor, Westinghouse Electric Corporation, Atlanta, Ga.

Appointed from its own membership to serve as a member of the Edison Medal Committee for the unexpired term ending July 31, 1953, of John D. Harper, resigned: D. D. Ewing, Head, School of Electrical Engineering, Purdue University, Lafayette, Ind.

James Travis Is Guest Speaker at Richland Section Meeting

The guest speaker at the September 25th dinner meeting of the AIEE Richland Section was Mr. James E. Travis, Assistant Manager of the Hanford Operations Office of the Atomic Energy Commission. Mr. Travis discussed "Structural Designs for Atomic Warfare," giving special emphasis and consideration to the electrical phases of the designs. His discussion was based on the studies which have been made at the site of atomic bomb blasts in Japan. He described the features of the power, lighting, and telephone systems which failed and which survived the atom blasts in Japan. Here the problems are the same and amount to protection from radiant heat, air pressure, winds, and sand blasting by the dust storms. He outlined the problems and the recommended practices to protect against the effects of the atom blasts. His discussion included a description of the methods whereby existing structures could be strengthened and the measures to be taken to reduce the seriousness of the blasts.

During the meeting F. J. Mollerus, retiring Richland Section Chairman, reviewed the past history of the Section since establishment in 1948. He outlined the steps which the Section has taken to reach national prominence in electrical affairs.

Mr. Mollerus handed the gavel to Mr. Gray Clifton, incoming Vice-Chairman who accepted in the absence of Chairman-elect R. B. Crow. Mr. Clifton briefly outlined the proposed program for the coming year of Richland Section activities.

Shown at the AIEE Richland Section dinner meeting are, left to right, F. J. Mollerus; Mr. Travis; G. M. Clifton; and W. J. Dowis, past Section Chairman

Student Badge

Under an action taken by the Board of Directors at its meeting on October 25, 1951, any Student member who has renewed his membership at the rate of $5.00 per year may, upon request to Institute headquarters, receive a plated vest pin or lapel button without charge. Each request should include the year number opposite the Student's name on his stencil address, and the address to which the badge should be mailed.

Aircraft Technical Conference Held in Hollywood, Calif.

A highly successful Technical Conference on Aircraft Electrical Applications, sponsored by the AIEE Committee on Air Transportation, was held at the Hollywood Roosevelt Hotel, Hollywood, Calif., on October 8, 9, and 10. A total registration of 341 indicated the judiciousness of timing the conference to coincide with the annual meetings and displays of the Society of Automotive Engineers and Aircraft Electrical Society in Los Angeles. More than one-third of those attending were visitors from distant aircraft centers and represented the military services, their technical and development organizations, civilian aeronautic committees, air frame manufacturers, airlines, and accessory manufacturers.

Warren V. Boughton, retiring Chairman of the Committee on Air Transportation, officially opened the conference on Monday morning before an attendance of 215. E. K. Sadler, Chairman of Los Angeles Chapter of AIEE, welcomed the many visitors.

Following the opening, the technical

At the speakers' table at the AIEE Technical Conference on Aircraft Electrical Applications during the luncheon on October 10 are, left to right, C. E. Gagnier, D. W. Fritz, W. V. Boughton, Lieutenant Colonel Dieffenderfer, C. R. Moore, Commander Pickett, E. K. Sadler, W. C. Bryant, Peter Duyan, Jr., and C. S. Milliken

sessions were inaugurated. Twenty-seven papers were presented during six sessions. Recent developments to increase the safety and efficiency of commercial and military aircraft were presented. The technical material encompassed and correlated recent work on aircraft electrical generating and distribution systems, control devices, cable, and environmental problems.

One of the meeting highlights was the conference luncheon on Wednesday. C. R. Moore, Master of Ceremonies, presented W. V. Boughton, who clearly outlined the past history and objectives of the Committee on Air Transportation. Dwain E. Fritz then accepted the Committee chairmanship for the 1951–52 fiscal year. E. K. Sadler discussed the activities of the aircraft section of AIEE as they are related to those of the Los Angeles Chapter.

The principal addresses were given by Commander Harry D. Pickett, Chief of Electrical Section, Bureau of Aeronautics, and Lieutenant Colonel James C. Dieffenderfer, Chief of Electrical Section, Wright Air Development Center. Commander Pickett presented the electrical problems as encountered in the fleet and stressed the necessity of standardization and ease of maintenance. Lieutenant Colonel Dieffenderfer presented the organization, purpose, and accomplishments of the Advisory Staff. This staff was recently appointed from representatives of the air frame manufacturers. They were informed by the Services of plans for future aircraft electric equipment. The staff then analyzed the needed power requirements and recommended electrical generation and distribution methods. He stressed the imperative need for co-operation and assistance from all organizations to obtain greater reliability of electric equipment on aircrafts. Lieutenant Colonel Dieffenderfer also re-emphasized the needs stressed by Commander Pickett.

On Thursday morning, the annual meeting of the AIEE Committee on Air Transportation was held under the direction of the new chairman, Dwain E. Fritz.

The operating committee for the conference was: H. F. Rempt, *Chairman;* W. C. Bryant, *Vice-Chairman;* C. E. Gagnier, *Program;* C. R. Moore, *Registration;* W. V. Boughton, *Sessions;* C. S. Milliken, *Financial;* W. L. Berry, *Secretary;* J. R. Harkness, *Arrangements;* and C. J. White, *Publicity.*

COMMITTEE ACTIVITIES

Editor's Note: This department has been created for the convenience of the various AIEE technical committees and will include brief news reports of committee activities. Items for this department, which should be as short as possible, should be forwarded to R. S. Gardner at AIEE Headquarters, 33 West 39th Street, New York 18, N. Y.

Communication Division

Committee on Telegraph Systems (*E. C. Chamberlin, Jr., Chairman; J. A. Duncan, Jr., Vice-Chairman; R. B. Shanck, Secretary*). This committee, together with the Radio Communications Systems Committee, is planning a jointly sponsored technical session for the Winter General Meeting. Several papers are in prospect covering new multiplexing techniques, both frequency-division and time-division, with applications in landline as well as radio. The interest aroused by last year's papers on this subject indicates that the session should be well attended.

A. G. Cooley, Chairman of the Facsimile Subcommittee, also is planning a technical conference to be held during the Winter Meeting to cover some of the numerous recent developments in this field. A similar conference was held in January 1950, and activity since that time indicates that another conference should be well received.

Committee on Wire Communications Systems (*L. G. Abraham, Chairman; G. B. Ransom, Vice-Chairman; P. G. Edwards, Secretary*). This committee held meetings on October 23, 1950, and on January 24, June 27, August 22, and October 24, 1951. By this means most members were able to attend at least one meeting. The committee has sponsored sessions at all general meetings during the past year and is planning some general interest papers at the New York meeting in January 1952. Plans are under way to co-operate in the Centennial of Engineering in the fall of 1952. The committee has co-operated with various session meeting committee chairmen in helping plan technical programs at sectional meetings. Questions of overlap of scope with committees in other divisions are being discussed with the other committees and specific proposals to delineate the fields are being prepared.

Industry Division

Committee on Feedback Control Systems (*S. W. Herwald, Chairman; F. E. Crever, Vice-Chairman; A. G. Kegel, Secretary*). In answer to considerable demand, a Conference on Feedback Control Systems will be held December 6 and 7, at the Chalfonte-Haddon Hall Hotel, Atlantic City, N. J. The purpose of the conference is twofold: to recapitulate important developments in techniques and components which have taken place in the field of feedback control systems during the past few years, and to present some of the important advanced developments. The presentation of the papers has been planned so that they will not be merely summaries or abstracts, but will be complete discussions in themselves. The program is given on page 1019 of the November issue of *Electrical Engineering.*

Registration will take place at the conference each day at 8:00 a.m. There w be no advance registration. The registration fee is $3.00. Hotel accommodations may be secured directly from the Chalfonte-Haddon Hall Hotel in Atlantic City, N. J.

Committee on Mining and Metal Industry (*A. C. Muir, Chairman; W. R. Harris, Vice-Chairman*). One of the activities which

this committee has considered most important is the development of a Manual for Committee Guidance, copies of which were sent to all members of the committee and the subcommittees. Copies can be made available to other committees. Committee members have found this manual to be very helpful to them.

A close liaison has been in effect with the Underground Power Committee of The American Mining Congress. At present the committee is co-operating with them in preliminary work on standards for cable sizes for "permissible" motors for mining.

The Western Mining Subcommittee is now arranging with The American Institute of Mining and Metallurgical Engineers to jointly sponsor a symposium on Ore Beneficiation to be held during the Summer General Meeting in Minneapolis in 1952.

Power Division

Committee on Carrier Current (*C. W. Boadway, Chairman; S. C. Leyland, Vice-Chairman (E); R. H. Miller, Vice-Chairman (W); B. W. Storer, Secretary*). At a recent meeting of the committee held at AIEE Headquarters, the several subcommittees and their personnel were reorganized with a view to increased active participation in the work of this committee.

Subcommittees 3, 4, and 5, as listed in the 1950 Year Book, have been amalgamated under "Subcommittee on Methods of Measurement and High Frequency Characteristics of Power Equipment and Transmission Lines."

The Subcommittee on Long Life Tubes has terminated its work since information on ruggedized and reliable tubes is now available in tube handbooks. However, all members of this subcommittee are assembling available data for inclusion in a final report.

Two subcommittee reports, "The Evolution of Power Line Carrier" and "Proposed Definitions Relating to Power Line Carrier," are scheduled for presentation at forthcoming meetings of the Institute. The latter report will complete the work of the subcommittee on carrier current terminology.

The other four subcommittees are continuing their work of assembling necessary material and tabulating data, and it is expected that with the proposed increase in personnel they will progress at an even greater rate.

Science and Electronics Division

Committee on Electronic Power Converters (*I. K. Dortort, Chairman; C. R. Marcum, Vice-Chairman; J. B. Pitman, Secretary*). At the end of the preceding administrative year, the subcommittee setup was changed somewhat to keep the structure functional with the work to be done.

The Electron Tube Subcommittee and the Committee on Electronic Power Converters will hold a 2-day Joint Tube Conference in Pittsburgh, Pa., on May 5 and 6, 1952.

Steps will be taken soon to publish in Advance-Copies-Only (ACO) form the report on the survey of operation of electronic power converters. It is planned to send copies to all users who contributed to the survey.

A Working Group of this committee is working on a comprehensive report on Cooling and Corrosion Problems in Mercury-Arc Rectifiers.

Work on Standards for Hot-Cathode Converters has lagged because of the pressure of other affairs on everyone involved. It is hoped that work can be resumed shortly and the project completed.

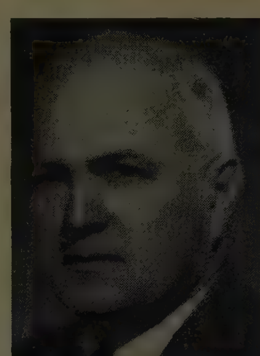
The bibliography of converter literature started some years ago is now in excellent shape and will be kept up-to-date by periodic supplements.

Committee on Instruments and Measurements (*John H. Miller, Chairman; J. G. Reid, Jr., Vice-Chairman, East; J. E. Hobson, Vice-Chairman, West; Ernst Weber, Secretary, East; W. S. Pritchett, Secretary, West*). The 1951 fall meeting of the committee was held on October 2. Twenty-eight members were in attendance, nearly half the total roster. Professor T. S. Gray reported for a Subcommittee on Organization with a new arrangement for the various subcommittees which was approved by all concerned. Essentially a new outline for grouping the subcommittee activities, it will go into effect in the near future. The development of a Power Test Code is progressing under the chairmanship of C. J. Zeller, the third draft having been circulated to the subcommittee. Plans are being made by the Joint Subcommittee on Telemetering for a West Coast Conference this coming spring. A great deal of interest in the matter of geophysical instruments, particularly in the fields of oil exploration, was reported by Chairman Miller, and it was thought that a subcommittee should be formed to cover geophysical instruments and measurements.

The Electric Welding Committee has requested advice on measurements and C. F. Savage has been appointed as a representative of the Instruments and Measurements Committee to assist them in their work.

AIEE PERSONALITIES.....

Elgin Barnett Robertson (M '24, F '45), President, Elgin B. Robertson, Inc., Dallas, Tex., was elected a Director of the AIEE by the Board of Directors at their meeting on October 25, 1951, for the unexpired term ending July 31, 1954, of A. G. Dewars, deceased. Born on June 4, 1893, in Meridian, Tex., Mr. Robertson was graduated from the University of Texas in 1915 with a degree in electrical engineering. He



E. G. Robertson

was with the Westinghouse Electric and Manufacturing Company (now the Westinghouse Electric Corporation) from 1915 to 1920, and then became chief electrical engineer for the Railway and Industrial Engineering Company, Greensburg, Pa., where he remained until 1924. In 1928, Mr. Robertson established the Elgin B. Robertson Company in Dallas, Tex., and since has been managing partner. When the Plastics Manufacturing Company was formed in 1939 he was made President. He joined the regional War Production Board as production engineer in 1942 and later was named regional utility engineer and regional manager of the production department. Mr. Robertson had just completed a 4-year term as AIEE Director (1947–51). He has actively served the Institute as Section Secretary (1937–38), Section Chairman (1938–39), and on the following AIEE committees: Membership (1944–46); Board of Directors (1947–51); General Applications Co-ordinating (1947–51); Registration of Engineers (1946–51, Chairman 1949–51); Planning and Co-ordinating (1946–51); and Professional Group Co-ordinating (1949–51).

Edwin S. Lammers, Jr. (M '34), electronics engineering supervisor, Westinghouse Electric Corporation, Atlanta, Ga., has been elected a Vice-President of the AIEE representing the Southern District (number 4) by the Board of Directors at their meeting on October 25, 1951, for the unexpired term ending July 31, 1953, of J. D. Harper. Mr. Harper resigned from the position because of a change of residence from the

E. S. Lammers, Jr.

Southern District to the South West District. Mr. Lammers was graduated from the Agricultural and Mechanical College of Texas in 1913 and then became associated with the Westinghouse Electric Corporation. In 1918 he joined the Electrical Department of the

ational Tube Company, Lorain, Ohio, maining for five years. Mr. Lammers turned to Westinghouse in 1923 as in-strial sales control supervisor and three ars later was made general engineer on dustrial applications, in which capacity remained until 1941 when he became ectronics engineering supervisor. Mr. mmers is a past Chairman of the AIEE orgia Section, (1949–50). He is a ember of the Institute of Radio Engineers, e Association of Iron and Steel Engineers, d the Georgia Engineering Society.

. L. Cisler (M '35, F '47), Executive Vice-esident, The Detroit Edison Company, etroit, Mich., has been appointed Presi-nt and general manager of the company. r. Cisler was graduated from Cornell niversity in 1922 with a degree in me-

W. L. Cisler

hanical engineering. From 1922 to 1941 e was associated with the Public Service lectric and Gas Company, N. J., working om the position of cadet engineer up to ssistant chief engineer. From 1941 to 943 Mr. Cisler served with the War Pro-uction Board supervising the scheduling nd production of power equipment, the o-ordination of construction of power rojects, and the development and allocation f equipment for lend-lease. In 1943 he ntered the United States Army and served n General Eisenhower's staff in Europe here he directed the re-establishment of tility services. Mr. Cisler became chief ngineer for The Detroit Edison Company n 1945 and was named Executive Vice-resident three years later. He is a member f The American Society of Mechanical ngineers. Mr. Cisler has actively served he AIEE on the following committees: ower Generation (1935–43, Chairman 940–42); Technical Program (1940–42); tandards (1941–42); Management (1947–2, Chairman 1948–49); and Professional roup Co-ordinating (1948–49).

llen Lehman, AIEE Student Member, The ity College, New York, has disappeared nd it is hoped that someone reading this rticle might have information leading to is whereabouts. He was to enter the senior lass at City College this fall as a major in lectrical engineering and student editor of he engineering magazine, The City College ector. A full description of him is as

Allen Lehman

follows: height, 5 feet, 9 inches; weight, 150 pounds; light complexion; dark brown hair, parted on left side; wears glasses all the time; has a small scar under chin. He left New York City July 1, and entered Canada on or about July 21. He wrote home regularly and his last letter was posted from Fort William, Ontario, Canada, August 8. He was wearing khaki brown United States Army woolen pants, Army field boots, tan utility jacket. He was carrying a United States Army mountain rucksack with metal frame. If you have any information about Allen Lehman, please communicate with his parents immediately. Their address is: Mr. and Mrs. George Lehman, 8305 20th Avenue, Brooklyn 14, N. Y.

W. J. Seeley (A '19, F '45), Professor and Head of Electrical Engineering, College of Engineering, Duke University, Durham, N. C., has been appointed Director of Research and Development for the College of Engineering. He also has been appointed Chairman of the Student Development Committee of the Engineers' Council for Professional Development. Professor Seeley has just completed a 2-year term as AIEE Vice-President of the Southern District (number 4) and has served on the following committees: Student Branches (1932–33); Research (1937–40); Basic Sciences (1945–50); and the Board of Directors (1949–51). He is a member of the Institute of Radio Engineers and Sigma Xi.

R. L. Biesele, Jr. (A '45, M '48), Head, Electrical Engineering Department, Southern Methodist University, Dallas, Tex., has been named Research Professor of Engineering. This position will allow him to devote full time to his research activities, particularly in the field of illumination. He received his engineering education at the University of Texas and became associated in 1936 with the Westinghouse Electric Corporation as lighting engineer. He served in that capacity until 1943, when he joined the faculty at Southern Methodist University. He was named Head of the Department of Electrical Engineering in 1946. He is a member of the American Society for Engineering Education and is a Director of the Illuminating Engineering Society. He is serving on the AIEE Education Committee.

G. R. Henninger (A '22, F '43), professor, electrical engineering division, Iowa State College, Ames, Iowa, has been appointed assistant director of the Engineering Extension Service at Iowa State College. In this capacity Mr. Henninger will have charge of the administration of adult education activities carried on by the Service throughout the state. Prior to joining the faculty at Iowa State College he was Editor of *Illuminating Engineering* and Director of Publications, Illuminating Engineering Society, New York, N. Y. His experience also includes holding the position of Editor of *Electrical Engineering* from 1933–48. In 1942, Mr. Henninger served as a civilian consultant in the office of the Secretary of the Navy and then for three years he served as a lieutenant colonel in the United States Army. He is a member of the American Society for Engineering Education and the Illuminating Engineering Society. He served on the AIEE Publications Committee (1948–49).

F. W. Tatum (A '42, M '45), professor of electrical engineering, Southern Methodist University, Dallas, Tex., has been named Chairman of the Department of Electrical Engineering. He received his technical education at the School of Engineering, Columbia University, receiving degrees of bachelor of science and master of science in electrical engineering. From 1935 to 1947 he was associated with the American District Telegraph Company, New York, N. Y., and held the position of engineering supervisor before becoming a member of the faculty at Southern Methodist University. He is a member of the Institute of Radio Engineers and the American Society for Engineering Education. Currently he is serving the AIEE as Chairman of the Committee on Student Branches.

L. K. Stringham (A '34, F '49), Engineering Vice-President, The Lincoln Electric Company, Cleveland, Ohio, has been appointed chief engineer for the company. His new duties will be in addition to those he already has as Engineering Vice-President. Mr. Stringham, who has an electrical engineering degree from Cornell University, has been with The Lincoln Electric Company since 1933. Mr. Stringham holds several patents on devices for electric control for automatic welding. He is a member of the American Welding Society and Eta Kappa Nu. He has served the Institute on the Electric Welding Committee (1945–49, 1951–52).

R. M. Casper (M '40), manager, Electrical Department, Allis-Chalmers Manufacturing Company, Milwaukee, Wis., has been made manager of the newly created Power Department. Mr. Casper joined the company in 1936 as a sales representative and after successive promotions was made manager of the Electrical Department in 1949. **F. W. Bush** (A '36, M '43), assistant manager, Electrical Department, Allis-Chalmers Manufacturing Company, Milwaukee, Wis., has been appointed assistant manager in charge of the electrical sections of the Power Department. Mr. Bush has been associated with the company since 1928. He has served the AIEE on the Management Committee (1947–52) and the Fortescue Fellowship Committee (1949–52).

300 Attend North Texas Section Meeting

At the September 25 dinner meeting of the AIEE North Texas Section, more than 300 members and guests attended. The Texas Electric Service Company of Fort Worth, Tex., acted as host for the meeting and, in addition to making arrangements for an inspection trip through their new Handley, Tex., Station, they provided a barbecue dinner for the entire group

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P. G. Agnew (A '12, M '19, Member for Life), consultant, American Standards Association, New York, N. Y., has been awarded a gold medal by the American Standards Association in recognition of a lifetime of service and leadership in the cause of standardization. Dr. Agnew served as first administrative head of the Association from the time it was founded in 1919 until his retirement to consultant status in 1947. He is the author of many pamphlets and articles on physics, electrical engineering, and standards. Dr. Agnew has actively served the AIEE on the following committees: Electrophysics (1918–20); Instruments and Measurements (1917–19); and Standards (1916–20).

C. H. Black (A '41, M '45), manager of engineering, construction materials division, General Electric Company, Bridgeport, Conn., has been appointed general manager of the company's Meter and Instrument Department at Lynn, Mass. He joined General Electric in 1924 and has served successively as application engineer on switchgear equipment, managing engineer for air circuit-breaker equipment, and manager of engineering for the Switchgear Department. He has served the Institute on the Protective Devices Committee (1944–45) and Switchgear Committee (1947–48).

C. C. Duncan (A '40), supply practises engineer, Operation and Engineering Department, American Telephone and Telegraph Company, New York, N. Y., has been appointed operating staff manager, Long Lines Department. His duties will include co-ordinating the plant, traffic, and commercial activities of the Long Lines Department in long-distance services.

F. K. McCune (A '33, F '49), manager of engineering, large apparatus division, General Electric Company, Schenectady, N. Y., has been appointed assistant manager of the company's engineering services division. He served on the AIEE Transfers Committee (1946–48).

W. F. Ogden (M '41), assistant chief engineer, Engineering Department, Hotpoint, Inc., Chicago, Ill., has been appointed manager of product planning in the marketing services division of the company. He will be located at the company's New York City offices. Mr. Ogden has been associated with Hotpoint, Inc., for 15 years serving as commercial engineer and assistant chief engineer. He has actively served the Institute on the following committees: Domestic and Commercial Applications (1942–46, Chairman 1942–44); Technical Program (1942–44); Standards (1942–44).

L. R. Ludwig (A '28, M '41), assistant to the vice-president in charge of industrial products, Westinghouse Electric Corporation, Pittsburgh, Pa., has been appointed Director of Engineering and Research, Atomic Power Division. Mr. Ludwig joined Westinghouse following his graduation from the University of Illinois in 1925 with a bachelor of science degree in electrical engineering. He served as a member of the AIEE Committee on Protective Devices (1938–44).

Sol Levine (M '50), assistant chief engineer, Edo Corporation, College Point, N. Y., has been appointed chief engineer of the electronics division of the company. Mr. Levine has been with the Edo Corporation since 1946. Previous to that he had been associated with the Bendix Aviation Corporation and the Crucible Steel Company. He is a member of the Institute of Radio Engineers, the Acoustical Society of America, and the American Physical Society. He holds several patents relating to sonar devices.

C. W. Eichhorn (A '35, M '46), design engineer, transformer division, Raytheon Manufacturing Company, Waltham, Mass., has accepted the position as head of the transformer division of Laboratories for Electronics, Inc., Boston, Mass. Mr. Eichhorn had been associated with the Raytheon Manufacturing Company for eight years and his experience prior to this included association with the Minneapolis-Honeywell Regulator Company and the American Transformer Company.

L. H. Middleton (A '31, M '36), Vice-President, The Electric Auto-Lite Company, Toledo, Ohio, has been appointed to the position of Director of Engineering. Mr. Middleton became associated with the company in 1933 in the position of executive engineer. His experience previous to that was as chief engineer, Moto-Meter Gauge and Equipment Company, Toledo, Ohio.

H. L. Hamilton (A '37, M '47), corrosion engineer, Keystone Pipe Line Company, Philadelphia, Pa., has been named to manage and direct the activities of the A. V. Smith Engineering Company, Balacynwyd, Pa. The company will conduct field surveys and studies leading to recommendations for the control of corrosion. Mr. Hamilton is a member of the National Association of Corrosion Engineers.

G. W. Acock (A '44, M '51), assistant chief electrical engineer, electrical wire division, John A. Roebling's Sons Company, Trenton, N. J., has been appointed product application engineer, Engineering Department, Rome Cable Corporation, Rome, N. Y. Mr. Acock had been associated with the John A. Roebling's Sons Company since 1934. He is a member of the American Society for Engineering Education and has served on the AIEE Insulated Conductors Committee since 1948.

Coleman London (M '49), section engineer, communication equipment engineering, Westinghouse Electric Corporation, Baltimore, Md., has been appointed manager of electronics service, electronics and X-ray division. Mr. London joined Westinghouse in 1938 after receiving a degree in electrical engineering from The Johns Hopkins University. He is the author of several technical papers on radar and communications and holds patents in these fields. He is a member of the Institute of Radio Engineers.

W. J. Warren (A '34, M '46), Head, Electrical Engineering Department, University of Santa Clara, Calif., has joined the staff of Shell Development Company, Emeryville, Calif. He received a doctor of philosophy degree in electrical engineering from the University of Illinois in 1936, and has been associated with the University of Santa Clara since 1941.

R. R. Longwell (A '42, M '49), engineering and service supervisor, Westinghouse Electric Corporation, Baltimore, Md., has been appointed engineering and service manager. Mr. Longwell has been with the company since 1924. Since then he has held various positions in the company's switchgear engineering and district engineering and service departments.

C. W. Schweers (A '37, M '47), New England regional manager, Allis-Chalmers Manufacturing Company, Boston, Mass., has been named Vice-President in charge of sales for the general machinery division

the company. Mr. Schweers, who became ssociated with Allis-Chalmers in 1930, also as served as manager of the firm's general achinery district sales offices in Houston, ex., and Los Angeles, Calif.

. C. **Kirkwood** (A '48), junior engineer, . C. Kirkwood and Associates, Kansas ity, Mo., has been made a member of the rm. He is a member of the National ociety of Professional Engineers, Tau Beta i, and Eta Kappa Nu.

. W. **Maas** (A '39), sales engineer, Sales epartment, Wagner Electric Corporation, hiladelphia, Pa., has been appointed anager of the San Francisco, Calif., office. Ir. Maas has been a sales engineer for the ompany since 1939.

I. P. **Kartalia** (A '45), assistant sales anager, Square D Company, Detroit, Iich., has been appointed manager of erchandise sales.

. I. **Cohn** (A '43, M '50), assistant professor f electrical engineering, Illinois Institute of echnology, Chicago, Ill., has been pro- oted to associate professor.

OBITUARY • • • •

lbert Lawrence Rohrer (A'87, M'88, Member for Life), retired, Maplewood, N. J., ied on October 18, 1951. He was born in armsville, Ohio, in 1856, and attended Ohio niversity. He entered the employ of the homson-Houston Electric Company, a pred- ecessor of the General Electric Company, in 884. Mr. Rohrer was electrical superin- endent of the Schenectady (N.Y.) Works of he company from 1892 to 1923, and advi- ory engineer from 1923 until 1926, when he etired. He recruited and supervised the raining of engineering personnel for the com- any from 1892 to 1914. In that period ,000 college graduates were brought to the eneral Electric Company. He was a mem- er of The American Society of Mechanical ngineers.

Herbert Milton Hazlett (A'26, M'35), gen- eral superintendent, Light and Gas Depart- ment, Monterrey Railway, Light and Power Company, Monterrey, Mex., died on July 11, 1951. He was born on December 1, 1899, in erome, Ariz., and was graduated with a achelor of science degree in electrical engi- neering from Tri-State College of Engineer- ng in 1924. He joined the Puerto Rico Power Light Company in 1926 as superin- endent of hydroelectric plants and was romoted to superintendent of power eneration in 1931, which position he held ntil 1942. Subsequently he joined the olivian Power Company at La Paz, olivia, as general superintendent and was ater appointed manager. In 1948 he be- ame associated with the Monterrey Rail- ay, Light and Power Company as general uperintendent.

eorge Kirlin (A'43), Vice-President, Can- da Wire and Cable Company, Ltd., Montreal, Quebec, Canada, died on September 2, 1951. He was born in Montreal, Quebec, Canada, on August 9, 1893, and joined the staff of the Standard Underground Cable Company of Canada, which later became the Canada Wire and Cable Company, Ltd., in 1914. Except for a period when he served with the Canadian Artillery during World War I his association with the company was uninterrupted. In 1930, Mr. Kirlin was appointed eastern district manager, and in 1949 he was appointed Vice-President of the company. He was a member of the Canadian Electrical Association.

Gustavo Lobo (A'01, M'11, F'12, Member for Life), retired, New York, N. Y., died on October 17, 1951. He was born on March 28, 1876, in Caracus, Venezuela, and was graduated from the School of Engineering of Columbia University in 1898 with the degree of electrical engineer. Mr. Lobo's career covered experience in the design, construction, and operation of electric light and power plants in various locations in Mexico. He also was associated with the Cambridge Gas, Electric Light and Power Company, Cambridge, Md., and was the founder of the Kelvin Engineering Company, New York, N.Y., and its President until his retirement in 1943.

Abram Adkins Cory (A'27), chief electronics engineer, Norfolk Navy Yard, Portsmouth, Va., died on September 30, 1951. He was born on January 19, 1903, in Luchou Fu, China, and was graduated from the University of North Carolina in 1926 with a bachelor of science degree in electrical engineering. He received his master of science degree in electrical engineering from the same institution two years later. Before joining the Norfolk Navy Yard Mr. Cory had been associated with the Durham Public Service Company, Durham, N.C., and had served with various companies in New York and New Jersey.

George Clare Harness (A'41, M'45), district engineer, Westinghouse Electric Corporation, Philadelphia, Pa., died on August 9, 1951. He was born in Galveston, Ind., on September 17, 1898, and was graduated from Purdue University with a bachelor of science degree in electrical engineering in 1922. From 1923 to 1928 he was assistant superintendent of transmission at the Pennsylvania Power and Light Company, Hazleton, Pa., and in 1928 he became engineer for the company in Allentown, Pa. Mr. Harness joined the Westinghouse Electric Corporation as an engineer in 1939, and a year later was made district engineer with headquarters in Philadelphia.

Earl R. Seymour (A'23), commercial engineer, General Electric Company, Pittsfield, Mass., died on October 4, 1951. He was born December 1, 1886, in Beach City, Ohio, and received a bachelor of arts degree from Western Reserve in 1910 and a bachelor of science degree from the Case School of Applied Science (now Case Institute of Technology) that same year. He became associated with the General Electric Company after graduation and served continuously with that company in various capacities for 41 years.

MEMBERSHIP • • • •

Recommended for Transfer

The Board of Examiners at its meeting of October 18, 1951, recommended the following members for transfe to the grade of membership indicated. Any objection to these transfers should be filed at once with the secretary of the Institute. A statement of valid reasons for such objections, signed by a member, must be furnished and will be treated as confidential.

To Grade of Fellow

Ballard, W. C., prof. of elec. engg., Cornell University Ithaca, N. Y.
Everhart, J. G., chief engr., transformer div., Line Material Co., Zanesville, Ohio
Gardner, M. L., engg. & service mgr., New England dist., Westinghouse Electric Corp., Boston, Mass.
Ingledow, T., vice pres. & chief engr., B. C. Electric Co., Vancouver, B. C., Can.
Jones, A. A., mgr., engg. dept., Anaconda Wire & Cable Co., Hastings-on-Hudson, N. Y.

5 to grade of Fellow

To Grade of Member

Beatty, W. J., sales engr., American Air Filter Co., New York, N. Y.
Bigbie, D. D., asst. elec. engr., California Packing Corp., San Francisco, Calif.
Cofer, J. W., planning engr., Toledo Edison Co., Toledo, Ohio
Flahie, C. E., trans. & dist. engr., The Toledo Edison Co., Toledo, Ohio
Friedrich, R. E., design engr., Westinghouse Electric Corp., East Pittsburgh, Pa.
Hays, G. T., engr., Dallas Power & Light Co., Dallas, Tex.
Henn, W. F., mgr. central station & trans. divs., General Electric Co., Philadelphia, Pa.
Koberg, M., genl. mgr., Almacen Koberg, Ltd., San Jose, Costa Rica, C. A.
Kranz, H. P., supt., overhead lines dept., Narragansett Electric Co., Providence, R. I.
MacKenzie, K. W., project engr., Raytheon Mfg. Co., Waltham, Mass.
McGinnis, C. F., asst. sales mgr., Elliott Co., Ridgway, Pa.
Miller, C. W., mgr., large power trans. engg. div., Westinghouse Electric Corp., Sharon, Pa.
Nagel, L. L., elec. engr., Research Corp., Bound Brook, N. J.
Olsen, E. C., test engr., Canadian General Electric Co., Ltd., Toronto, Ont., Can.
Parker, S. R., electronic dev. engr., International Resistance Co., Philadelphia, Pa.
Peterson, J. D., engr., eclipse-pioneer div., Electrical Controls Lab., Bendix Aviation Corp., Teterboro, N. J.
Porterfield, R. H., district mgr., Allis-Chalmers Mfg. Co., Providence, R. I.
Rogers, A. L., asst. chief engr., United Merchants Labs., Inc., New York, N. Y.
Rotta, A. E., mgr., Public Utility Dist. No. 2, Raymond, Wash.
Scott, R., asst. prof. elec. engg., University of Toronto, Toronto, Ont., Can.
Shima, R., chief engr., General Electronics, Inc., Paterson, N. J.
Wachter, R. V., elec. engr., Aluminum Co. of America, Vancouver, Wash.
Weaver, J. W., application engr., Elliott Co., Ridgway, Pa.
Woodward, R. V., chief engr., Dowzer Electric Machinery Works, Inc., Mount Vernon, Ill.
Wyman, J. H., project engr., Bendix Aviation Corp., Teterboro, N. J.
Young, R. E., mgr., Etobicoke Hydro-Electric Commission, Toronto, Ont., Can.

26 to grade of Member

Applications for Election

Applications for admission or re-election to Institute membership, in the grades of Fellow and Member, have been received from the following candidates, and any member objecting to election should supply a signed statement to the Secretary before December 25, 1951, or February 25, 1952, if the applicant resides outside of the United States, Canada, or Mexico.

To Grade of Member

Curry, H. H., Lockheed Aircraft Corp., Marietta, Ga.
Gopalakrishna, H. V., Indian Institute of Science, Bangalore, India
Graf, F. G. (re-election), Westinghouse Elec. Corp., New York, N. Y.
Methorst, G. C., Heemaf N. V., Hengelo (O), Netherlands
Soni, C. M., New Pratap Spg., Wvg., & Mfg. Co., Dhulia (West Khandesh), India

5 to grade of Member

Snow Depth Measurements Reported by Frequency-Modulated 2-Way Radio

One of the most recent unique applications of supervisory control and telemetering equipment is that of transmitting snow depth measurements from mountain tops and other isolated points.

From an economic standpoint, it is vitally important to efficiently use all the water from natural precipitation, particularly in the western states. This requires accurate measurement of the moisture as it falls and as it is stored in the snow pack in the mountains. In the past this has been accomplished only by laborious sampling and an insufficient number of measurements.

During the past two years, however, the United States Weather Bureau and the Corps of Engineers of the United States Army have developed a thickness gauge using radioactive isotopes of common metals to measure the water equivalent of snow.

These artificial radioactive elements recently have become available in practical quantities as a result of the development work undertaken by the Atomic Energy Commission. The isotopes, like natural radioactive elements such as radium, may emit alpha, beta, and gamma rays. Of these, only the gamma rays appear to have sufficient energy to penetrate a deep snow pack.

The isotopes are planted beneath the ground surface. By measuring the intensity of the radiation of the isotopes after it has passed through the snow, the water equivalent depth of the snow can be found.

The Geiger-Mueller tube was chosen as the sensing device to measure the radiation intensity because it is rugged and can withstand the conditions of operation imposed upon it. It is simple and provides an output that can be readily used in electronic circuits.

So that no one has to be present at the measurement point, usually on an isolated mountainside, Motorola radio equipment is used to transmit automatically the data to the central recording station.

The battery-operated transmitters and receivers are mounted in small stainless-steel cases which themselves are weatherproof. Nickel-cadmium storage batteries are chosen to furnish power because of their excellent low temperature characteristics.

In the radio units, individual sections such as oscillators, frequency dividers, transmitter and receiver stages, and the time switches are individually removable for easy servicing in the field. This is the same principle of design as in the Handie-Talkie portable radiophones.

From the data gathered and transmitted by this equipment, preparations can be made to store a portion of the water as it comes down from the mountains. Commitments to both hydroelectric power and irrigation water supplies can be made with full assurance of their fulfillment.

Typical repeater station located on a mountain for receiving signals from several radioactive snow-gauge stations and sending them on to the recording station

Automatic Selective Pneumatic Tube System Installed by Bridgeport Company

The automatic selective pneumatic tube system introduced in this country by the International Standard Trading Corporation, an associate of the International Telephone and Telegraph Corporation (IT&T), and now in operation at the Housatonic plant of the Bridgeport (Conn.) Brass Company, represents one of the most practical and economical approaches to the problem of interoffice communication.

In most pneumatic tube installations of this size, separate sending and receiving lines are necessary to establish intercommunication. The only alternative is to have all carriers routed to a central control point, to be redispatched manually to their respective destinations. The disadvantages of this method are that it not only necessitates the services of a full-time attendant but requires the construction of a greater number of tubes to and from the main dispatching room.

This system, which utilizes the mechanical brain features of automatic dial telephony, was developed by Mix and Genest, a German subsidiary of IT&T. Unlike conventional pneumatic tube systems, the new interoffice messenger is both automatic and selective. A notable feature is a special selective dial on the carrier which permits the sender to forward his message or article to any one of nine stations in the plant without the intervention of an operator or a central dispatcher. It is this ability to route

Future Meetings of Other Societies

American Society of Refrigerating Engineers. Annual Meeting. December 2–5, 1951, Hotel Roosevelt, New Orleans, La.

Hydraulic Institute. January 30–February 1, 1952, Seaview Country Club, Absecon, N. J.

Institute of Aeronautical Sciences. 20th Annual Meeting. January 28–February 1, 1952, Astor Hotel, New York, N. Y.

National Association of Manufacturers. Annual Meeting. December 5–7, 1951, Waldorf-Astoria Hotel New York, N. Y.

Plant Maintenance Conference. Third Annual Meeting. January 14–17, 1952, Convention Hall, Philadelphia, Pa.

Society of Plastics Engineers, Inc. Eighth Annual National Technical Conference. January 16–18, 1952, Edgewater Beach Hotel, Chicago, Ill.

The American Society of Mechanical Engineers. Annual Meeting. November 25–30, 1951. Haddon Hall Hotel, Atlantic City, N. J.

carriers automatically to any given point that makes the new system so radically different from the conventional, manually operated installation.

On each of the carriers are two rings stamped with the numbers zero to nine. These rings are adjusted to the number corresponding to the receiving station. As the carrier is inserted in the tube, it travels by vacuum through the sending line to the automatic central installation or transfer control point. While en route, electric fingers pick up the dialled number and flash it to the central station. Here the relay panel or brain of the system reads the signal, actuates the appropriate switches, and immediately speeds the carrier through to the correct outgoing line and station. On arrival, the relays are released and the station is ready to receive the next carrier.

The relay panel, in addition to determining the course of the carriers, counts the number which pass through each loop, provides the appropriate space interval between travelling carriers, and flashes alarm signals should any failure occur in any part of the system.

If the carrier has been put into the tube with the ends reversed, or if the numbered rings have been set for a nonexistent receiving station, the carrier will be discharged into a reject tube at the switching center, and a light will announce the inability of the system to determine its proper destination. Visual indication also is given of the number of lines in operation, blower performance, blown fuses, and vacuum failure.

After the message is inserted into the carrier, the operator adjusts the dials on the carrier to the number of the laboratory station, and inserts the carrier into the sending inlet

Solenoid switching devices at the central station are actuated by a master relay panel. These switching devices start the carrier on its way to its proper destination

Engineering Societies of U. S. and Europe Confer in Holland

A conference of representatives from the Engineering Societies of Western Europe and the United States was held in The Hague, Holland, at the investigation of the Koninklijk van Ingenieurs, from September 17–21, 1951. Representatives of the following engineering institutions were present: Societe Royal Belge des Ingenieurs et des Industriels, Belgium; Dansk Ingeniørforening, Denmark; Suomalaisten Teknikkojen Seura and Tekniska Foreningen i Finland, Finland; Societe des Ingenieurs Civils de France, France; Koninklijk Instituut van Ingenieurs, Holland; Den Norske Ingeniorforening, Norway; Svenska Teknologforeningen, Sweden; Schweizerischer Ingenieur- und Architekten-Verein, Switzerland; The Institution of Civil Engineers, The Institution of Mechanical Engineers, The Institution of Electrical Engineers, United Kingdom; American Society of Civil Engineers, The American Society of Mechanical Engineers, American Institute of Electrical Engineers, United States.

The Conference agreed that the following recommendations should be brought to the attention of the governing bodies of the participating societies: 1. That definitions of the terms Professional Engineer and Engineering Technician be made which would outline the qualifications and the duties of the two groups which would facilitate understanding between the participating societies of the Western European Engineering Conference. It was emphasized that it is not the intention of the Conference to frame definitions which would have any effect in dealing with national legislation in the countries concerned. 2. Interchange of views on principles and methods of engineering education. 3. Further consideration to the relationship of the Conference with UNESCO. 4. Participating societies should keep the Conference Secretariat informed of conferences, meetings, and other dates to avoid clashing of the societies' activities. 5. Continue study of abstracting services. 6. Facilities for visiting members be extended to the participating societies of the Commonwealth Conference and UPADI (Federation of Pan American Engineering Societies).

The following resolutions were passed by the Conference: 1. The name of the Conference shall be abbreviated to EUSEC. 2. The Conference resolves to retain in being a Working Party who have studied and reported upon the definitions of the terms Professional Engineer and Technician, in order to consider and report upon any comments received from the councils of the participating societies. 3. The Conference resolves to supply information of Conference activities to the Conference of Engineering Institutions of the British Commonwealth and UPADI. 4. Liaison with other engineering conferences of engineering societies. 5. Study the activities of the newly established International Federation of National Associations of Engineers which seems to duplicate the aims and objectives of the Conference. 6. Admittance of new members. 7. Exchange of information on bodies interested in engineering. 8. Encouragement to be given to visits from students' groups. 9. Introduction of a biannual bulletin. 10. The next meeting will be held in Paris, France, in 1953.

Standardized Steam Plants Goal of REA Economy Program

Borrowers from the Rural Electrification Administration (REA) soon will be building standardized steam plants and already are purchasing the main items of equipment according to standard specifications.

REA electric distribution-line standardization was a major factor in reducing construction costs at the outset of the program, and standardization of steam plant construction is hoped to have a similar result. For instance, REA officials say that by carefully arranging equipment in a steam power plant and providing space for operation that is ample but not wasteful, the cubage of the building under consideration has been cut to about half of that which is often used.

In the past, practically all major steam power plants have been individually tailored. Standard specifications will permit components to be ordered largely from standard production lines in standard sizes.

For the past year the Steam Plants Section of REA's Power Division has been developing the standards for REA steam power plants. REA's Technical Standards Committee already has approved a number of standards for components. As a result of this standardization, time, money, and materials will be saved in construction. The plants will be designed to operate with a high degree of efficiency.

The first step taken was the standardization of the heat cycle—the arrangement of equipment for turning steam into electric energy—turbine generators, condensers, boiler feed pumps, deaerators, and evaporators. Then these elements themselves were standardized. This has been done for 16,500- and 22,000-kw units while designs for 33,000-kw and 44,000-kw units also are under way.

Steam generator (boiler) standardization plans still are being worked out. The varieties in fuel and methods of firing contribute to the difficulties. Preliminary layouts for steam generators already have been drawn, based on information obtained from boiler manufacturers. These plans

are being worked out in collaboration with manufacturers and others.

Convincing savings in time, energy, and expense for everyone concerned, including the manufacturers, have resulted from the REA standards already adopted. Further savings will be derived from the uniform design and construction of components and buildings.

GE and Cornell University to Sponsor Electronics Center

A pioneering venture in educational and industrial research co-operation was revealed recently in a plan announced jointly by the General Electric Company and Cornell University for the establishment of an advanced electronics center at Ithaca, N. Y.

Initially, the center will occupy a large modernized laboratory building located on Cornell property adjacent to the Ithaca East Hill airport. Modification of the building, already begun, is scheduled to be complete by February 1952. Employment at the center during its first year of operation is expected to reach 80 people, more than half of them scientists.

The project's over-all purpose "is to carry out advanced study and development in the field of electronics, and at the same time provide scientists and engineers with teaching and educational opportunities of a type never previously established."

An immediate objective of the new center will be an attempt "to fulfill the rapidly increasing needs of both industry and the armed services for additional military electronics research and development facilities." It will supplement the company's electronics research activities at Electronics Park, Syracuse, and Schenectady, N. Y.

Projects to be carried on at the center during the present national emergency may include the development of such items as control systems for guided missiles, electronic countermeasures, and infrared systems.

Activities at the center will be directed by a four-man management team—two men of industry and two men of science. Their combined skills and experience represent fully the abilities required in the various scientific, industrial, military, and academic aspects of such a pioneer venture.

Representatives of Cornell will have a definite part in the approval of projects to be assigned to the center by General Electric.

Cornell will give faculty appointments to a number of staff members of the center, in accordance with their qualifications. They will be granted full faculty privileges on the campus, and may be used by the University to teach appropriate classes. Their work at the center will be arranged so that such teaching assignments at Cornell will not be interrupted by their laboratory work for the company.

Certain members of the faculty and staff of Cornell may be employed by the General Electric Company on a part-time salary basis or as consultants. Graduate and fifth-year students at Cornell may be employed on a part-time basis to perform work at the center. Graduate students working at the center also may conduct work on their graduate theses or dissertations by mutual agreement of representatives of the University and the company.

Ocean Depth Measurements Accurate to 6,000 Fathoms

A new type of echo-sounding equipment which permits accurate readings of the ocean's depth from 10 feet to 6,000 fathoms has been developed for the United States Navy by the Edo Corporation, College Point, N. Y. The new equipment is the first of its type developed which will measure accurately extreme ocean depths. Previous deep soundings required elaborate equipment on special survey vessels with single soundings made from stationary positions.

Designated officially as the *AN/UQN*, the new equipment makes possible far greater range and accuracy than has been achieved in previous echo-sounding equipment. More effective and immediate use of the information supplied by echo-sounding is accomplished by improved readability. For depths ranging from 10 feet to 100 fathoms, the readings are made from a cathode-ray tube. Deeper soundings, from 100 to 6000 fathoms, are recorded on graph paper.

Most dramatic tests so far for the new *UQN* developed by Edo have been made off Puerto Rico over the Brownson Deep where depths of 4,270 fathoms, or 25,620 feet, were recorded with accuracy and ease. Presumably, the *UQN* will provide continuous readings of any known ocean depth including the Mindanao Deep off the Philippines which is 5,800 fathoms.

Two units make up the *AN/UQN*—the transducer which transmits and receives signals from the bottom of the ship and the main electronic unit located usually on the bridge or in the navigating room. Main reason for the *UQN*'s increased accuracy and range is its increased power. Despite this increased power the *UQN* is just half the size and weight of previously used Navy equipment.

Cleveland Trolley Coaches Feature New Electric Drive

The 50 new trolley coaches being placed in service by the Cleveland Transit System, Cleveland, Ohio, are among the first in the nation to be equipped with the new motor and control system developed recently by the Westinghouse Electric Corporation.

The heart of the new coaches is the Westinghouse superseries motor, which retains the advantages of the series motor formerly used in trolley coaches but has additional features as well. When teamed with the newly developed Electrocam control system, it makes possible smoother starts and gliding, rather than jerking, stops.

When used for traction purposes, the motor provides an infinite number of accelerating rates for smooth starts. When power is removed, it operates as a brake and brings the coach to a gradual halt. This brake will be used for normal stops, but air brakes will be used in an emergency.

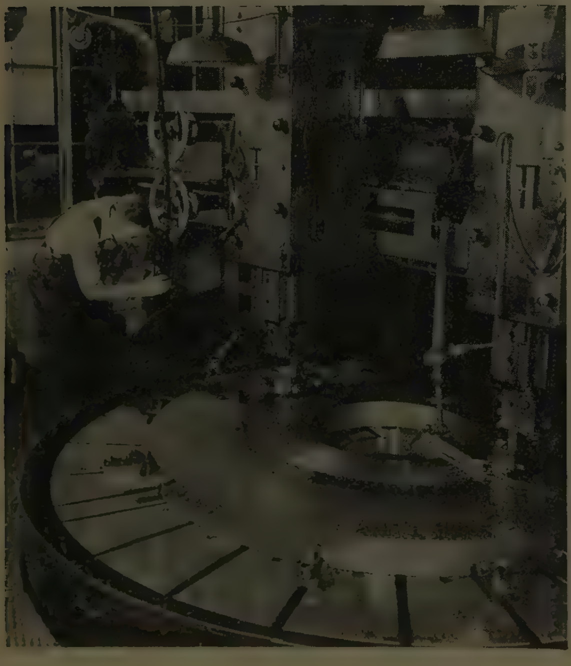
The simplicity of the electric equipment, plus easy maneuverability and the absence of noise and fumes, mean less driver fatigue and, consequently, greater safety.

U. of Calif. Gets Synchrotron for Cancer Treatment Studies

An atom-smasher, developing the most powerful X-ray beam ever generated specifically for the treatment of cancer, is now being assembled at the University of California School of Medicine, San Francisco.

The synchrotron, designed and constructed by the General Electric Company, produces an X-ray beam of 70,000,000 volts. With it, University of California scientists will do

Giant Bearing Gets Superfine Polish



A mirror-smooth finish is put on the rotating element of a hydrogenerator thrust bearing in this final grinding operation at General Electric's large Motor and Generator Department, Schenectady, N. Y. The bearing must support a load of almost 2,000,000 pounds, including the weight of all rotating parts of the generator and hydraulic turbine plus the thrust of the turbine. The superfine polished surface is necessary to establish a film of oil only a few thousandths of an inch thick which separates the rotating element of the bearing from the stationary part

some pioneering research on the possibility that ultrahigh-energy X rays have some advantages in treating deep-seated cancer.

The new cancer-fighting weapon is being reassembled in a 2-story building constructed especially to house it and its associated laboratory. Total cost of the machine and the building, all financed by Atomic Energy Commission funds, is about $500,000.

The new synchrotron will not be used in the treatment of human patients for some time to come. The early work will be devoted to determining the effect of ultrahigh-energy X rays on animals. The machine will have considerable flexibility, since it can be adjusted between 20–70,000,000 volts. Work with the 20,000,000-volt betatron, presently the most powerful X-ray weapon in use for cancer treatment, indicates it is possible to put a higher dose of radiation in deep-seated tumors than with lower voltage machines. At 70,000,000 volts this effect may be even more pronounced.

When assembled, the 16-ton machine will be mounted on huge trunnions, somewhat like an ordinary X-ray machine. By means of powerful auxiliary machinery, the magnet can be moved to adjust the X-ray beam.

RCA to Sponsor Fellowships for Study in Electronics

Predoctoral Fellowships in Electronics supported by the Radio Corporation of America (RCA) and administered by the National Research Council will be available for the academic year 1952–53. It is the purpose of these fellowships to give special graduate training and experience to young men and women who have demonstrated marked ability in the general field of electronics, either as a branch of electrical engineering or as part of the general field of physics. A fellow must be a citizen of the United States with training in electronics equivalent to one year beyond the bachelor's degree.

Applications must be filed before January 10, 1952; awards will be announced about March 15. Further information may be obtained from the Fellowship Office, National Research Council, 2101 Constitution Avenue, Washington 25, D. C.

General Electric Announces New Step-Motor Impulse Counter

A newly designed step-motor impulse counter to provide 100 per cent accuracy up to 60 counts per second has been announced by the Special Products Division of the General Electric Company.

Designed to cover counting ranges above those possible with electromechanical counters and below those in which scalers normally are required, the device has a counting range which makes it especially useful in high-speed production counting.

The step-motor impulse counter consists of a step motor with a resetting-type register, and a power supply enclosed in a steel case. The step-motor and register assembly are mounted on the power supply enclosure, which contains an electronic switch and a high-voltage supply capable of supplying the power requirements of a phototube preamplifier. The counting assembly can be removed easily and placed in a remote position such as a control panel.

LETTERS TO THE EDITOR

INSTITUTE members and subscribers are invited to contribute to these columns expressions of opinion dealing with published articles, technical papers, or other subjects of general professional interest. While endeavoring to publish as many letters as possible, Electrical Engineering reserves the right to publish them in whole or in part or to reject them entirely. Statements in letters are expressly understood to be made by the writers. Publication here in no wise constitutes endorsement or recognition by the AIEE. All letters submitted for publication should be typewritten, double-spaced, not carbon copies. Any illustrations should be submitted in duplicate, one copy an inked drawing without lettering, the other lettered. Captions should be supplied for all illustrations.

Electric Machinery Textbooks

To the Editor:

In the study of a-c machinery such as motors, generators, and transformers, alternating magnetic fluxes as well as alternating currents are involved. Textbooks treat alternating currents very methodically. The various quantities are measured in practical units and their relations are indicated clearly. However, as a rule no corresponding treatment of alternating fluxes is presented. Consequently the student does not develop a clear conception of the actions of alternating fluxes. It seems that if textbooks would supply a method of analysis of alternating fluxes similar to that applied to alternating currents, it would be a material aid in developing an understanding of a-c machines.

Alternating fluxes operate according to natural laws similar to those governing alternating currents. The alternating flux may lag its magnetomotive force in time just as alternating current may lag its electromotive force, and the power expended in the alternating magnetic circuit can be measured in terms of magnetomotive force and flux and their time angle relation just as the power expended in an alternating electric circuit is measured in terms of electromotive force and current and their time angle relation. However, since the electromotive force is in time quadrature with the flux, while the magnetomotive force is in phase with the current, the angle of current lag is complimentary to the angle of flux lag. Consequently, in dealing with alternating fluxes, the sine of the time angle between magnetomotive force and flux must be used where the cosine is used with alternating currents. When voltage and current are in time quadrature and the power factor is zero, magnetomotive force and flux are in phase. In this case the sine of their time angle is zero and the watts are also zero. When magnetomotive force and flux are in time quadrature, electromotive force and current are in phase, the power factor is unity, the sine of the time angle between magnetomotive force and flux is also unity, and the power equals the product of magnetomotive force and flux.

To further illustrate the relations between the alternating electric and magnetic circuits, consider the fundamental equations for electromotive force and magnetomotive force:

$$E=\frac{4.45\ F\phi N}{10^8} \tag{1}$$

where E=volts; F=frequency; ϕ=flux in lines of force; and N=number of turns.

$$M=NI\ldots\ldots I=M/N \tag{2}$$

where M=ampere turns or magnetomotive force.

$$P=EI\cos\theta_E \tag{3}$$

where I=current; P=watts; θ_E=time angle between E and I.

Equation 3 represents the power expended in an a-c circuit. Substituting in this equation the values of E and I in terms of the alternating magnetic circuit, derived from equations 1 and 2, and also substituting $\sin\theta_M$, the time angle between M and ϕ in place of $\cos\theta_E$, since θ_E and θ_M are complimentary angles and $\cos\theta_E=\sin\theta_M$, we have

$$P=\frac{4.45\ FN\phi}{10^8}\frac{M}{N}\sin\theta_M$$

$$P=\left(\frac{4.45F}{10^8}\right)M\phi\sin\theta_M$$

Power systems are operated at fixed constant frequencies. For a given frequency the quantity in the parentheses becomes a constant, reducing the equation in this case to:

$$P=KM\phi\sin\theta_M$$

or

$$P=\frac{267}{10^8}M\phi\sin\theta_M \text{ for 60 cycles}$$

The difficulty in the practical application of this equation appears to be the lack of a system of practical units applying to the magnetic circuit. The inductive effect in the electric circuit causing the current to lag the electromotive force is recognized in textbooks as reactance. The corresponding inductive effect in the magnetic circuit, causing the flux to lag the magnetomotive force, generally is neglected entirely. Reluctance is recognized as corresponding to resistance but there appears to be no practical unit of reluctance corresponding to the ohm.

While the student naturally develops a knowledge of these relations through experience, it seems that if they were presented in textbooks devoted to a-c machinery it would enable him to develop a clear understanding of the subject at an earlier stage. Since the magnetic circuit is equally as essential as the electric circuit in a-c machines, it seems that alternating fluxes should receive attention equal to that of alternating currents in textbooks devoted to a-c machinery.

EDWARD BRETCH

(Century Electric Company, St. Louis, Mo.)

NEW BOOKS • • • • •

The following new books are among those recently received at the Engineering Societies Library. Unless otherwise specified, books listed have been presented by the publishers. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books in question.

ADVANCED DYNAMICS. 2 Volumes. By E. H. Smart. Macmillan Company, New York, N. Y., and London, England, 1951. Volume I, 419 pages; Volume II, 420 pages; diagrams, tables, $8^3/_4$ by $5^3/_4$ inches, linen, $12.00 per set. Volume I, Dynamics of a Particle, gives a full discussion of rectilinear motion with acceleration directed towards and away from a fixed point, oscillating particles, simple harmonic motion with unresisted and damped vibration, and impulsive forces applied to problems of impact. Volume II, Dynamics of a Solid Body, provides a full analysis of d'Alembert's principle and the equations of motion in two and three dimensions, Lagrange's equations and generalized co-ordinates, the motion of a top, Hamilton's equations, and general theorems on impulses.

AIR CONDITIONING IN SUMMER AND WINTER. By R. E. Holmes. Second edition. McGraw-Hill Book Company, New York, N. Y.; Toronto, Ontario, Canada; London, England, 1951. 352 pages, illustrations, diagrams, charts, tables, $9^1/_2$ by 6 inches, cloth, $5.75. An elementary but comprehensive treatment of the science of air conditioning. Intended for those who wish to work in that field, the book presents such information as will give an understanding of the practical problems of designing and installing air-conditioning apparatus and of the principles and methods by which these problems are worked out. New material has been added in this edition on heat pumps, adsorption systems, water chillers, compressors, panel-heating systems, packaged air conditioners, dehumidifiers, and so forth.

(THE) ALGEBRA OF VECTORS AND MATRICES. By T. L. Wade. Addison-Wesley Press, Cambridge 42, Mass., 1951. 189 pages, diagrams, tables, $8^3/_4$ by $5^3/_4$ inches, linen, $4.50. This is an elementary expository presentation of matrix and vector algebra, use being made of basic concepts of modern algebra, that is, group, integral domain, field, ring, basis, dimension, and isomorphisms concepts. The book serves as a prerequisite for work in matrix and tensor calculus and is intended for students, engineers, and other scientists.

APPLIED MECHANICS FOR ENGINEERS. By Sir Charles Inglis. Cambridge University Press, American Branch, New York, N. Y., 1951. 404 pages, diagrams, charts, tables, 10 by 7 inches, linen, $7.50. This comprehensive textbook begins with the fundamental principles of rigid-body statics and the use of graphical methods in problems. The 18 succeeding chapters cover taut wires and catenaries, framework stresses and deformations, friction, kinematics, harmonic and circular motions, moments of inertia and momentum, the principle of energy, gyroscopic principles and applications, and aspects of the vibration problem.

AUTOMATIC FEEDBACK CONTROL. By W. R. Ahrendt and J. F. Taplin. McGraw-Hill Book Company, New York, N. Y.; Toronto, Ontario, Canada; London, England, 1951. 412 pages, illustrations, diagrams, charts, tables, $9^1/_4$ by $6^1/_4$ inches, cloth, $7.50. The material in this new text on the analysis and design of automatic feedback control systems is divided into two parts: discussion of the theory of automatic control, and a detailed treatment of the types of problems encountered in industry. Examples of the various classes of instruments are presented, showing both functional and constructional requirements. The author covers the field of servomechanisms, speed governors, and of temperature, pressure, flow, and liquid level controls.

PRACTICAL ELECTRICITY AND MAGNETISM. By M. Rubin. Chemical Publishing Company, New York, N. Y., 1951. 356 pages, diagrams, tables, $8^3/_4$ by $5^1/_2$ inches, cloth, $7.50. This book is an elementary survey of electricity and magnetism, with a special emphasis on recent developments in magnetism. Separate chapters are devoted to electrostatics, electric currents, electric meters and measurements, magnetism, electronics, electric conductivity of gases, practical applications of electricity, and recent developments. Such topics as transmission lines, lighting, telegraphy, telephony, radio, television, and radar receive brief treatment.

PRINCIPLES OF ELECTRICAL ENGINEERING. By W. H. Timbie, V. Bush, and G. B. Hoadley. Fourth edition. John Wiley and Sons, New York, N. Y.; Chapman and Hall, Ltd., London, England, 1951. 626 pages, illustrations, diagrams, charts, tables, $8^1/_2$ by $5^1/_2$ inches, linen, $6.50. Written for electrical engineering students, this book is intended as a text for a first course on the basic principles upon which modern electrical engineering rests. Some of the more important topics and methods stressed in this fourth edition are: advanced methods for analyzing electric and magnetic problems, powerful methods of circuit analysis, the fundamental problems of the electric and magnetic fields, and the relation of these problems to circuit analysis.

SYNTHESIS OF ELECTRONIC COMPUTING AND CONTROL CIRCUITS. (Annals Volume 27 of the Computation Laboratory of Harvard University.) Published by the Harvard University Press, Cambridge, Mass., 1951. 278 pages, illustrations, diagrams, charts, tables, $10^3/_4$ by $7^3/_4$ inches, cloth, $8.00. This book provides a systematic and practical approach to the logical design of circuits for use in electronic computing and control, with special emphasis on the design of digital computing machinery. Only the elementary rules of algebra are employed in the mathematical analysis of the electronic circuits presented and in the development of methods for the rapid and economical design of electronic switching apparatus.

TABLES OF $n!$ AND $\Gamma(n+{}^1/_2)$ FOR THE FIRST THOUSAND VALUES OF n. (Applied Mathematics Series Number 16.) United States Bureau of Standards, Washington, D. C., 1951. 10 pages, tables, 10 by 8 inches, paper, $0.15, for sale by Government Printing Office, Washington 25, D. C. These tables give values for factorial n to 16 significant figures and for the accompanying function to eight significant figures. The values are tabulated in such a way as to facilitate their use by covering 100 integers per page.

TABLES RELATING TO MATHIEU FUNCTIONS, prepared by the Computation Laboratory of the National Bureau of Standards. Published by Columbia University Press, New York, N. Y., 1951. 278 pages, tables, charts, $10^3/_4$ by 8 inches, cloth, $8.00. Tables given in this volume provide the following: characteristic values of Mathieu's differential equation; special coefficients; joining factors; and other specialized values of relevant nature. The introduction includes a general survey of the characteristics of the functions, methods of handling them, interpolations, and the methods used in computing the tables. Values in the tables are given to seven or more decimal places.

TELEVISION PRINCIPLES. By R. B. Dome. McGraw-Hill Book Company, New York, N. Y.; Toronto, Ontario, Canada; London, England, 1951. 291 pages, diagrams, charts, tables, $9^1/_4$ by 6 inches, linen, $5.50. Based on a series of lectures constituting a training course for employees of the General Electric Company, this book provides a practical treatment of the principles and theory of all stages of television transmission and reception. It is assumed that the reader is familiar with the fundamentals of calculus, d-c and a-c theory, radio-frequency phenomena, and vacuum tubes. Although the treatment is thorough, only the essential mathematics are employed.

THEORY AND DESIGN OF TELEVISION RECEIVERS. (McGraw-Hill Television Series.) By S. Deutsch. McGraw-Hill Book Company, New York, N. Y.; Toronto, Ontario, Canada; London, England, 1951. 536 pages, illustrations, diagrams, charts, tables, $9^1/_4$ by 6 inches, linen, $6.50. Written for the senior or graduate electrical engineering student, this book presents a physical explanation for the behavior of various television receiver circuits, develops the mathematical theory concerning the circuits, and discusses the practical design of receiver circuits. Each of the basic sections of a television receiver, from the antenna to the picture tube, is treated in separate chapters. One chapter is devoted to receiver servicing techniques. Television transmitters and color television are not discussed.

PERFORMANCE OF A PISTON-TYPE AERO-ENGINE. By A. W. Morley. Sir Isaac Pitman and Sons, Ltd., London, England, 1951. 143 pages, charts, diagrams, tables, $8^3/_4$ by $5^1/_2$ inches, linen, 25s. Of interest to those engaged in the design of aircraft and aircraft power units, this small volume gives an account of the author's research into the behavior of the piston-type engine under varying conditions of flight. The first part deals with aero-engine altitude laws and their particular application to a Merlin engine. The remainder considers the combination of a piston unit and exhaust gas turbine.

STARKSTROMTECHNIK. Teil I. By E. v. Rziha. Eighth edition revised. Verlag von Wilhelm Ernst and Sohn, Berlin, Germany, 1951. 303 pages, illustrations, diagrams, charts, tables, $8^1/_4$ by $5^3/_4$ inches, paper, 24 D.M. Part I of a set on heavy-current technology, this book is devoted to the physical principles of electricity. In Section I, the electromagnetic field theory is discussed on the basis of Maxwell's principles, and the ionization theory of electricity is presented. Section II considers the electrical measurements including common apparatus, circuits, and measuring methods. The remaining sections deal with the electrical characteristics of metals and of organic and inorganic insulating materials, and with rectifiers and accumulators.

TRANSIENTS IN POWER SYSTEMS. By H. A. Peterson. John Wiley and Sons, New York, N. Y.; Chapman and Hall, Ltd., London, England, 1951. 361 pages, illustrations, diagrams, charts, tables, $9^1/_4$ by 6 inches, linen, $6.50. Written for those engaged in or studying for the field of power system and apparatus design, this book organizes and consolidates our present knowledge of electric transients in power systems, with particular emphasis on power system overvoltages. Specific cases are utilized, and a variety of situations are examined in detail. The book deals both with nonlinear and complex linear circuits. Some 500 references are listed chronologically and by author in the bibliography.

PAMPHLETS • • • • •

The following recently issued pamphlets may be of interest to readers of "Electrical Engineering." All inquiries should be addressed to the issuers.

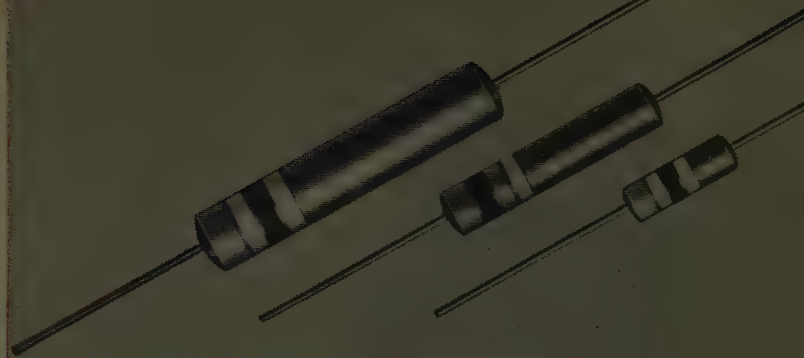
Index to NEMA Standards Publications. This index is to aid the users of National Electrical Manufacturers Association (NEMA) Standards Publications in choosing those which would best meet their individual needs. Copies available on request from the Engineering Department, National Electrical Manufacturers Association, 155 East 44th Street, New York 17, N. Y.

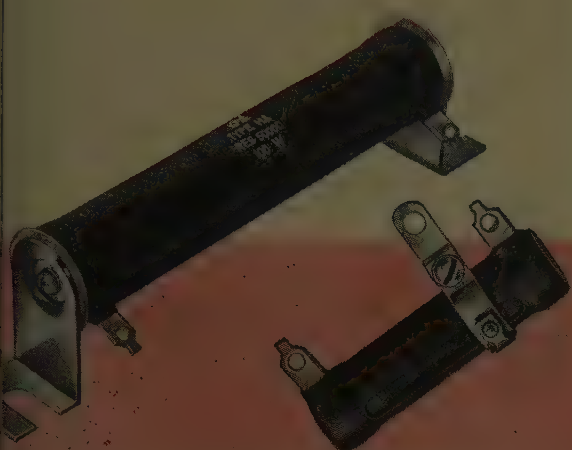
Electric Stairways Buyer's Guide. Information about the electric stairway and its function in moving people conveniently and economically in stores, banks, office buildings, transportation terminals, restaurants, theaters, factories, and other buildings. Available sizes are listed and information is given on price data, applications, and arrangement and layout of stairways. 32 pages. Booklet *B-4582* available from Mr. E. B. Dawson, Department T, Elevator Division, Westinghouse Electric Corporation, Jersey City, N. J.

Screw Thread Gauges and Gauging. This standard for gauges and gauging practice is supplementary to the American Standards Association Standard *B1.1* and is designed to facilitate adherence to thread dimensions of that standard, with resultant interchangeability of product, without modifying or restricting its requirements as to limits of size. $4.00 per copy. Available from Publication Sales Department, The American Society of Mechanical Engineers, 29 West 39th Street, New York 18, N. Y.

The How Book of Cost Cutting Materials Handling. Concerned with basic background material covering types of skids, pallets, and other industrial handling tools. Contains a comprehensive plan for evaluating present handling methods through an engineering analysis. Available upon request from the Yale and Towne Manufacturing Company, 11,000 Roosevelt Boulevard, Philadelphia 15, Pa.

essential



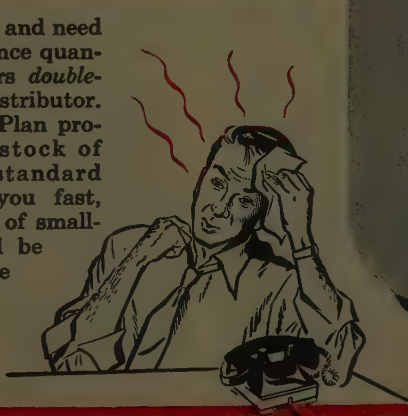


Temperature coefficients cover many resistance values in IRC Type BW Insulated Wire Wound Resistors. At ½, 1 and 2 watts, they are exceptionally stable, economical units for low range application such as meters, analyzers, spark suppression units, TV circuits, low power ignition circuits. Resistance elements are wound uniformly on insulated core. Molded phenolic housing protects against humidity and grounding. Noise and aging are negligible. Technical data Bulletin B-5 contains full details.

sides unusually rapid dissipation of heat, IRC Fixed d Adjustable Power Wire Wound Resistors give lanced performance in every characteristic. Special ment coatings are designed for low range high tempera- e requirements—or for maximum protection against treme atmospheric conditions. For exacting, heavy-duty plications—high voltage bleeders, bias supply, grid d filament dropping resistors—PWW's are available a full range of sizes, types and terminals. Leading dustrial, aircraft and broadcasting users have specified em for more than 14 years. Technical data Bulletin C-2 es complete information.

For extremely fast heat dissipation, the unique mounting brackets of Type MW Wire Wound Resistors actually transfer heat from chassis to outside. Other radical departures from conventional design give MW's widest adaptability to individual requirements. MW's are flat wire wound resistor strips, permanently enclosed by high pressure molding in a special mica-filled phenolic compound. Special feet permit mounting on any flat metal surface. Low initial cost, lower mounting cost, flexibility in providing taps at low cost, and savings in space, all offer amazing economies. Ask for technical data Bulletin B-2.

hen you're in a hot spot and need perimental or maintenance quan- ies of standard resistors *double- ick,* phone your IRC Distributor. C's Industrial Service Plan pro- des him with a full stock of iformly dependable standard istors; he can give you fast, und-the-corner delivery of small- der requirements. We'll be d to send you his name d address.



wer Resistors • Voltmeter Multipliers • ulated Composition Resistors • Low Wattage re Wounds • Volume Controls • Voltage iders • Precision Wire Wounds • Deposited rbon Precistors • Ultra-HF and High Volt- e Resistors • Insulated Chokes

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TERNATIONAL RESISTANCE COMPANY
401 N. Broad Street, Philadelphia 8, Pa.
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INTERNATIONAL RESISTANCE COMPANY
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Please send me complete information on the items checked below:—

☐ Advanced BT Resistors (B-1) ☐ BW Resistors (B-5)
☐ Power Wire Wounds (C-2) ☐ MW Resistors (B-2)
☐ Name and Address of nearest IRC Distributor

NAME__________

TITLE__________

COMPANY__________

ADDRESS__________

CITY__________ ZONE____ STATE____

J. F. ARNDT & CO., ADV. AGENCY

INDUSTRIAL NOTES . . . .

Marks Made Sales Manager of Rome Cable. Frederick S. Marks has been made sales manager of the Rome Cable Corporation.

United States Rubber Purchases Chicago Company. The United States Rubber Company has acquired the assets of the Chicago Die Mold Manufacturing Company, custom molder of plastic radio cabinets, dials, and other plastic products. The business will be operated as Chicago Die Mold, Division of the parent company. The former owner, E. A. Petersen, will remain as manager.

Stackpole Opens Pennsylvania Plant. A branch plant for the manufacture of electronic components has been opened in Kane, Pa., by the Stackpole Carbon Company.

Hubbard Election. Erling Wessel has been elected a member of the Board of Directors of Hubbard and Company. Mr. Wessel joined the Hubbard organization 35 years ago as a sales engineer.

Tenn-Tex Alloy and Chemical to Construct New $1,000,000 Plant. The newly formed Tenn-Tex Alloy and Chemical Corporation has announced plans to build a $1,000,000 plant in Houston, Tex., to produce ferromanganese, ferrosilicon, and other alloys. The plant will import approximately 5,000 tons of manganese ore a month through the Port of Houston from Cuba, India, South Africa, Mexico, and South American countries.

Sprague Appointment. James C. P. Long has been appointed to the Washington, D. C., engineering staff of the Sprague Electric Company of North Adams, Mass. Mr. Long was formerly head of the Material Co-ordination Section of the Bureau of Aeronautics, United States Navy Department.

G-E News. The General Electric Company has announced the formation of six new operating divisions which include the majority of the departments which constituted the former large and small apparatus divisions. The new divisions, with their headquarters locations, are as follows: Turbine Division, Schenectady, N. Y.; Motor and Generator Division, Schenectady, N. Y.; Transformer and Allied Products Division, Pittsfield, Mass.; Measurements and Industrial Products Division, Lynn, Mass.; Switchgear and Control Division, Philadelphia, Pa.; and the Components Products Division, Fort Wayne, Ind.

The General Electric Company also has announced that its Major Appliance Division has officially established headquarters in Louisville, Ky. Formerly headquartered at Bridgeport, Conn., the division has its principal offices and mailing address at 310 West Liberty Street, Louisville, until an administration building is constructed at Appliance Park in nearby Buechel.

Canadian Aviation News. Canadian Aviation Electronics, Ltd., Montreal, Canada, has announced formation of a subsidiary company, CAE (Overseas) Ltd., 41 Kingsway, London, W. C. 2, England. Wing Commander G. C. Cunningham, O.B.E., has been named managing director. The company also has announced the appointment of H. Arnold Cowan as its new production manager.

NEW PRODUCTS . .

Fault or Cross Locater. A new testing and fault-locating instrument enables trouble shooters and electrical maintenance men to determine the exact location of faults or crosses by a direct meter reading. The instrument, developed by R. F. Miller and Sons, Harvard, Neb., is a portable device which can detect the exact location of line-to-line or line-to-ground crosses and is not affected by stray or parasitic currents invading ground connections. A built-in ohmmeter measures resistance from 0 to 2 megohms. Current for ohmmeter and neutralizer is supplied by a self-contained battery. The instrument detects the location of a fault or cross on any conductor which has a resistance of at least 0.1 ohm for each 50,000 ohms of resistance of the cross or fault. Further information may be obtained from R. F. Miller and Sons.

Portable Engine Analyzer. A new portable engine analyzer which electronically detects, locates, and identifies detailed ignition and mechanical troubles in power plants containing any number of cylinders has been developed by the Sperry Gyroscope Company. A cathode-ray tube screen on the analyzer shows the flight engineer or engine mechanic the internal operating condition of the engine while it is running. It warns of cylinder and accessory failures such as bad spark plugs, sticking or damaged valves, and preignition before they can become serious. The analyzer is designed for high-altitude airborne use as well as for ground use. It is also applicable to monitoring troubles in aircraft accessories and in any spark-ignition type engine. Principal feature of the new analyzer is a new timing adjustment which makes setting of the timing generator on the engine unnecessary. By turning a knob shaft on the panel of the instrument, the operator can synchronize the analyzer accurately to any angle of the engine's rotating crankshaft. The cathode-ray pattern is calibrated in degrees of engine crank angle. Calibrations are read on a continuous dial of the "cycle selector" control which moves the cylinder events across the screen. This calibration tells the operator exactly when a particular event

(*Continued on page 24A*)

Everybody Wants

—BECAUSE EVERYBODY PROFITS!

GOOD VOLTAGE REGULATION pays dividends all around. Customers get all the electricity they need. And they get full value from the power they pay for because their equipment performs better and lasts longer.

But accelerated growth is pushing peak loads near estimates made a few years ago for 1953, and regulation must be achieved in the face of expanding loads and material shortages.

Now more than ever, your experienced Allis-Chalmers representative can help you utilize the wide line of A-C equipment to solve your power distribution — and production — problems. Allis-Chalmers, Milwaukee 1, Wisconsin. A-3488

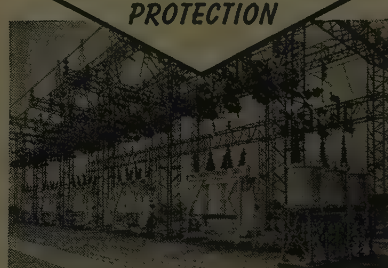
Ruptor and *Regulex* are Allis-Chalmers trademarks.

It Pays to Keep Pace with Machinery Progress

EASY INSTALLATION

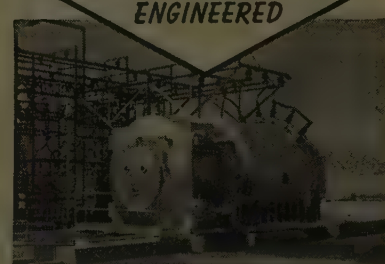
DUPLEX SWITCHBOARDS are factory assembled for economical installation. Convenient centralized secondary control for primary circuits assures good voltage regulation at the beginning of the line.

POSITIVE PROTECTION



OIL CIRCUIT BREAKERS team up *Ruptor* quick-quench interruptors with mechanically trip-free pneumatic or solenoid operators to minimize system voltage variation by prompt isolation of system faults.

CUSTOM ENGINEERED



SYNCHRONOUS CONDENSERS — used indoors or out — supply reactive kva to regulate voltage and stabilize large transmission systems. Air or hydrogen cooled. *Regulex* control adds fast response to changes.

CHALMERS

A-C ALLIS-CHALMERS

(Continued from page 18A)

is occurring in terms of engine cycle time. The analyzer can operate on any power line frequency from 50 to 500 cycles. The Sperry Gyroscope Company, Division of The Sperry Corporation, Great Neck, N. Y., will supply any further details on the instrument.

Expulsion-Type Lightning Arrester. A new De-ion expulsion-type lightning arrester, type *LX*, for protecting distribution apparatus incorporates a new method of limiting power follow current on systems having fault currents as high as 20,000 amperes. It is available from the Westinghouse Electric Corporation, Box 2099, Pittsburgh, Pa. A spiral fiber filler provides longer lightning-arrester life and positive protection by lengthening the power arc path to four times the original spark path. As a result, the power follow current is limited to a fraction of the available fault current. Although the arc path is lengthened considerably, spark-over values are kept low by high field stresses between the upper electrode and the metal shield surrounding the fiber arc chamber. A steel-reinforced arc chamber and the spiral groove in the fiber filler, which store gases generating during surge discharge, make the lightning arrester capable of withstanding surge currents in excess of 65,000 amperes. Built to AIEE and National Electrical Manufacturers Association Standards, the type *LX* lightning arrester is available in ratings of 3, 6, and 9 kv, and will be available later in ratings of 12, 15, and 18 kv. The Westinghouse Electric Corporation will furnish any further information.

Small Synchronous Motor. A small synchronous motor which operates on the reluctance principle, has no brushes, slip rings, rotating coils, or permanent magnet, has been announced by the Allis-Chalmers Manufacturing Company. It can be built to operate continuously at any voltage below 250 volts, either single phase or polyphase. It develops 8 ounce-inch starting torque and 0.8-inch synchronous torque. No starting equipment is required, the motor being able to start and pull into step at any frequency from 10 to 400 cycles. This motor is the first of new Allis-Chalmers developments being made available to original equipment designers on an experimental basis. It is one of various products developed primarily for military or special industrial equipment. Any inquiries should be addressed to the Allis-Chalmers Manufacturing Company, Industrial Press, General Machinery Division, Milwaukee 1, Wis.

A-C Voltage Regulator. Sorensen and Company, Inc., 375 Fairfield Avenue, Stamford, Conn., has announced a new unit, Model *1001* a-c line voltage regulator with a regulation accuracy of +0.01 per cent over a load range of 1 to 1,000 volt-amperes. Input is 95 to 130 volts a-c, single phase, 55 to 65 cycles; output voltage is adjustable from 110 to 120 volts a-c.

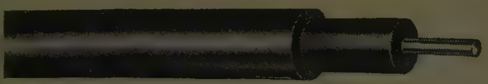
(Continued on page 42A)

Insure Your Power Load With RoMarine - RoPrene

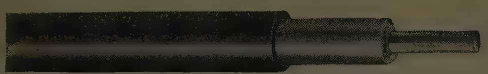
ALL-PURPOSE POWER CABLES

Street Lighting Cables

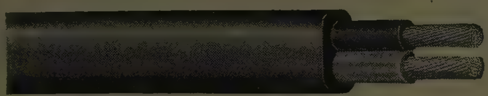
Rome manufactures a wide range of high and low voltage cables for underground, or overhead wiring of series and multiple lighting systems . . . *designed to meet your requirements.*



RoZone*-RoPrene Series Street Lighting Cable—5000 Volts



RoLene-Rome Synthinol* Series Street Lighting Cable—5000 Volts

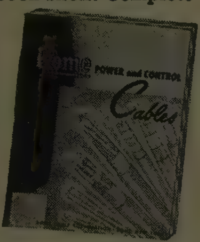


RoLene Ornamental Pole and Bracket Cable—
4000 to 12000 Open Circuit Voltage

JUST OFF THE PRESS!

The New Rome Power and Control Cable Catalog

This new sixty-page catalog will be an important addition to your book shelf! Complete in every detail, it includes descriptions, test data, specifications and suggested applications for all Rome Power and Control Cables. You'll find it invaluable for specifying. Mail coupon below today!



*T. M. REG.

You can't beat RoMarine-RoPrene for secondary network circuits, underground entrances, street lighting, or general purpose wiring. Exceptionally versatile, it is equally at home in country or city . . . can be installed direct in earth, in underground ducts, conduit or in air. If it's RoMarine-RoPrene you *know* you're right.

For long, economical service life RoMarine-RoPrene gives you *double protection* against costly circuit failures. RoMarine insulation affords high resistance to heat and moisture. The RoPrene (Neoprene) sheath has excellent resistance to oils, acids, alkalies, corrosive fumes, flame and abrasion. Its wide acceptance attests its popularity . . . hundreds of thousands of feet in service have proved its dependability.

RoMarine-RoPrene is less costly, easier to handle, tap and splice than lead sheathed cables. It is unaffected by electrolysis, extreme temperature changes and installed underground provides insurance against power outages from destructive storms. Its versatility reduces inventory.

IT COSTS LESS TO BUY THE BEST

Copper wire mill products are a Controlled Material under N.P.A. Controlled Materials Plan. USE YOUR CMP ALLOTMENT.

ROME CABLE Corporation
ROME · NEW YORK
and
TORRANCE · CALIFORNIA

(*Continued from page 24A*)

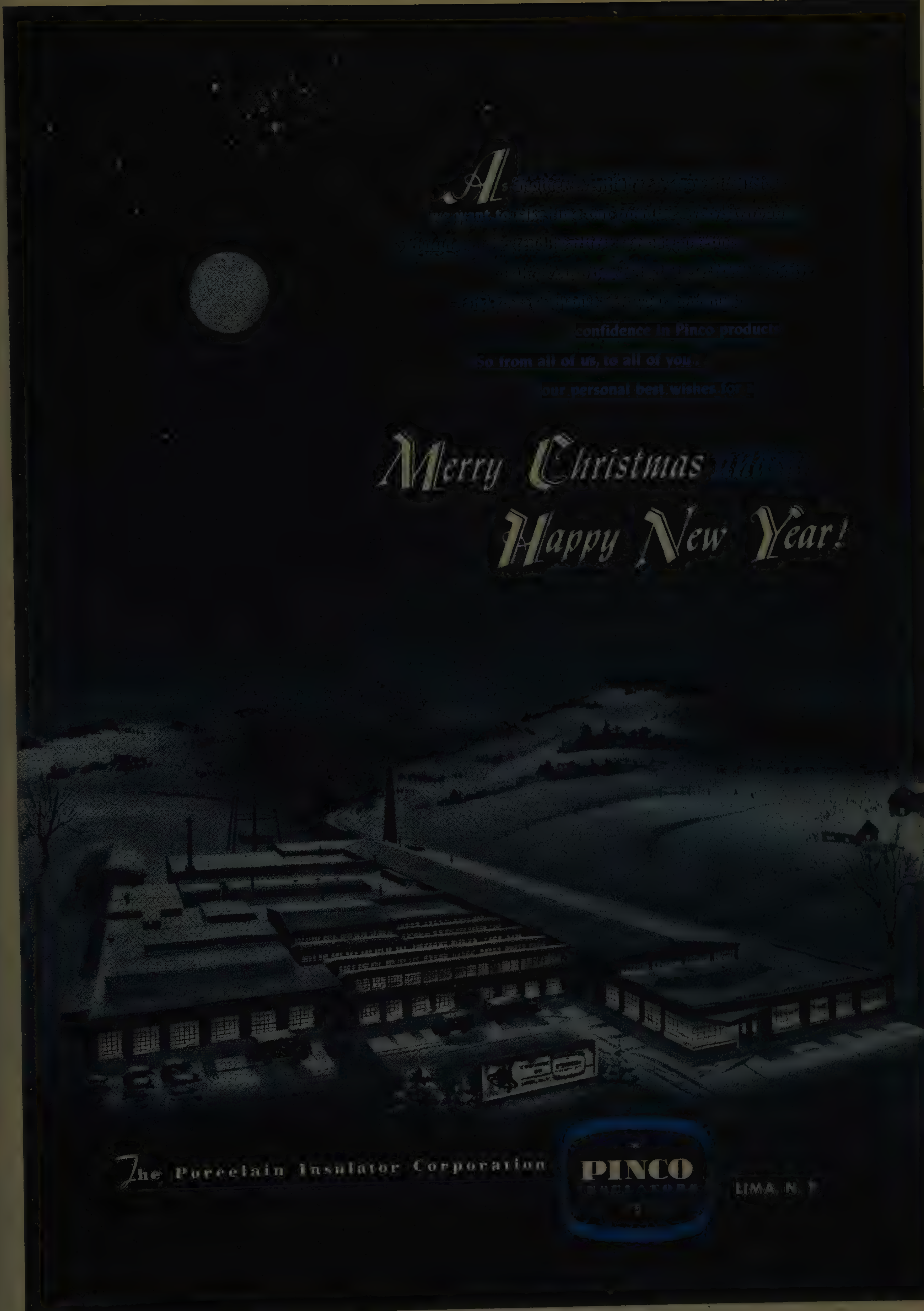
The accuracy is guaranteed at room temperature, for a resistive load, an input variation of +10 per cent, and over a 2-to-1 load change. Data sheets and further information may be obtained from Sorensen and Company.

Electronic Scanning System. An electronic scanning system designed to monitor automatically and continuously up to 270 separate processing temperature points has been developed by the Minneapolis-Honeywell Regulator Company. The new system records only those temperatures which deviate beyond a preset limit. It includes an audible alarm that permits immediate correction of excess temperatures. It is applicable for steam-generating stations, in chemical, petroleum, and processing industries, and in the manufacture of synthetic fibers and yarns where the temperature of the feed material supplying spinnerettes must be maintained at specific levels to eliminate costly defects in the product. Additional information on the scanning system may be obtained from the Minneapolis-Honeywell Regulator Company, Brown Instruments Division, Wayne and Windrim Avenues, Philadelphia 44, Pa.

Daylight Illuminometer. A recording daylight illuminometer, consisting of a Speedomax Recorder and a specially designed illuminometer cell assembly, has been announced by the Leeds and Northrup Company, 4934 Stenton Avenue, Philadelphia 44, Pa. As a remote reporter to utility load dispatchers in their task of anticipating lighting load changes, this equipment provides an automatic means for recording daylight intensity directly in foot-candles. The cell unit and the recorder are designed to operate together as a calibrated assembly. The recorder has an approximately logarithmic scale for maximum detail of record in the zone of principal interest. The cell is a refined United States Weather Bureau design for mounting atop a mast or in any dominant location. Using a barrier-layer photocell, the assembly is designed for collecting total illumination of sun and sky, and for filtration to match the photocell spectral response to the mean visibility curve of the human eye. The cell may be several hundred feet from the recorder or, for remote measuring over long distances, transmitting and receiving recorders can be supplied. More detailed information may be obtained from the Leeds and Northrup Company.

New Type Electric Connector. The Salsbury Corporation has perfected a new electric connector which conforms to AN specifications, but is lighter, shorter, and devoid of clamps, thereby eliminating need for most right-angle connectors. This new connector performs any standard connector task, as well as those met by special weatherproof, waterproof, acidproof, and vibration resistant connectors. This is accomplished by providing all lead wires into the connector with an individual packing gland, compression-sealed against

(*Continued on page 44A*)


confidence in Pinco products
So from all of us, to all of you
our personal best wishes for
Merry Christmas
Happy New Year!
The Porcelain Insulator Corporation
PINCO

(*Continued from page 42A*)

moisture, acid, fumes, and atmospheric changes. Wires in given harness arrangement are thrust through the compression nut and the compression plate for the given size plug or receptacle; each wire is threaded through a tapered collet and crimped or soldered into a pin or socket contact; pins or sockets are then arranged in the Teflon, Mycalex, or phenolic resin insert in proper order, the tapered collets fitting into tapered holes in tapered inserts; socket or pin insert with wiring is then slipped into the connector shell, the rear half of which is slightly tapered and keyed to receive the insert with its mating keyway; and then the compression plate is aligned with the key in the shell and the compression nut, when tightened, exerts sufficient force to bind all components into an integral whole, while effecting an individual seal for each wire. This design results in an electric connector whose shell can be mounted in a desired fixed position prior to the reception of necessary wiring, with each wire so securely held in place that wire fracture will take place before slippage through the collet. The Salsbury Corporation, Electrical Division, 1161 East Florence Avenue, Los Angeles 1, Calif., will supply any further details.

VPI. An economical method of preventing rust and corrosion of metal parts, in the presence of air and moisture, is provided by "VPI" crystals, a slightly volatile amine nitrate made available by the Shell Oil Company, 50 West 50th Street, New York 20, N. Y. Being slightly volatile at atmospheric temperatures, VPI gives off vapors which are carried by convection and diffusion to all surfaces of the metal, where they condense to provide a thin protective layer. It can be applied by enclosing the parts to be protected with it; by blowing it into an area to be protected; or by putting it into a water or alcohol solution and covering the metal parts in tote boxes. VPI will arrest corrosion at any advanced stage. More complete details on VPI may be obtained from the Shell Oil Company.

TRADE LITERATURE

Electronic Tubes. Essential characteristics of every conceivable type of receiving tube apt to be found in any home receiver—amplitude modulation, frequency modulation, or television—are described fully in a spiral-bound 107-page notebook recently issued by the Tube Sales Section, Tube Divisions, Electronics Department, General Electric Company, Schenectady, N.Y. Data presented include those characteristics and ratings essential to fast, efficient, trouble shooting. Basing diagrams for each type are shown also. The notebook, entitled, "Essential Characteristics," is available from the Tube Sales Section of the General Electric Company for the price of $0.35.

Thin Electrical Steels. New test data and information on thin electrical steels are

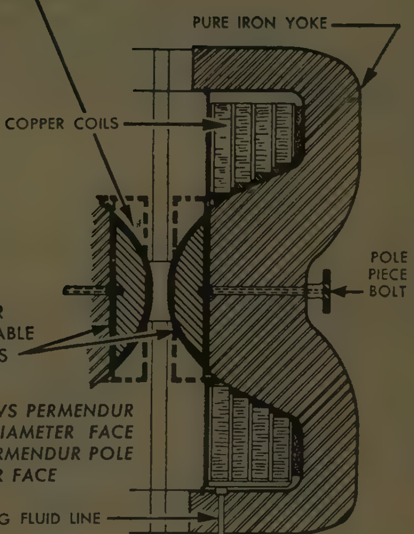
(*Continued on page 52A*)

PERMENDUR*

gives you

- ☆ **High Magnetic Saturation**
- ☆ **High Permeability at very high Flux Densities**
- ☆ **High Value of Positive Magnetostriction**
- ☆ **Design Possibilities for Savings in Weight, Space and Materials**

Typical use of Permendur in the ADL ELECTROMAGNET
(ARTHUR D. LITTLE, Inc.)



Sectional Detail of Yoke Half

Permendur is available in Forgings, Castings, Hot-Rolled Bars and Plates to meet your design needs for form or shape. *Write for information*

*Manufactured under license arrangements with Western Electric Co.

W&D 3929

THE ARNOLD ENGINEERING COMPANY
SUBSIDIARY OF ALLEGHENY LUDLUM STEEL CORPORATION
General Office & Plant: Marengo, Illinois

(*Continued from page 44A*)

presented in a booklet, "Armco Thin Electrical Steels," which may be obtained from the Armco Steel Corporation, Middletown, Ohio.

66 Hints. "66 Hints to Simplify Design and Reduce Spring Costs" is a new bulletin published by The Newcomb Spring Corporation, 3902 Seventh Avenue, Brooklyn 32, N.Y. It has been designed to help both spring designers and purchasers do a better job by pointing out ways and means of specifying for lower costs and faster delivery. The bulletin, *NS500*, may be obtained upon request.

Instruments. The Brown Instruments Division of the Minneapolis-Honeywell Regulator Company has issued four new bulletins: bulletin *B15-12* contains characteristics of the Brown Electronik continuous balance system; bulletin *B15-13* contains characteristics of measuring circuits used in Brown Electronik potentiometers; catalogue *8000* describes vane type electric contact controllers; and bulletin *1051* describes indicating pyrometers and resistance thermometers. All of these bulletins may be obtained from Station 40, Minneapolis-Honeywell Regulator Company, Brown Instruments Division, Wayne and Windrim Avenues, Philadelphia 44, Pa., upon written request.

Plastics. A new 24-page booklet explains plastics to the layman. Entitled "Facts about Plastics," it is available from The Richardson Company, 2764 Lake Street, Melrose Park, Ill.

Titanium. The current issue of AL QUARTERLY, published by the Allegheny Ludlum Steel Corporation, contains information concerning titanium metal. Entitled "Titanium—Up-to-Date," the booklet is available upon request to the Public Relations Department, Allegheny Ludlum Steel Corporation, 2020 Oliver Building, Pittsburgh 22, Pa.

Tracerlab. Tracerlab, Inc., has issued a new 107-page catalogue, *C*, which contains complete specifications and descriptions of their nucleonic and mechanical equipment and chemical compounds. The catalogue may be obtained from Tracerlab, Inc., at 130 High Street, Boston 10, Mass.

Pressure Connectors. Bulletin *66*, issued by The Thomas and Betts Company, Inc., 76A Butler Street, Elizabeth, N.J., describes their complete line of pressure (solderless) connectors. It may be obtained upon request.

Catalogues in Miniature. The South Bend Lathe Works, South Bend 22, Ind., has published two miniature catalogues, numbers *5104* and *5119*, describing their precision machine tools and attachments and accessories, respectively. These catalogues, only $2^1/_2$ inches by $1^5/_8$ inches, are available from the company upon request.

(*Continued on page 66A*)

ores are wound of oriented silicon steel. Wind-
ng machines are semi-automatic, stopping when
roper thickness of winding is reached. End of
ore strip is spot welded.

Following winding of the cores, they are annealed in bell-type furnaces in a nitrogen atmosphere and are then given an initial test for losses as illustrated above.

lacing windings into position over U-shaped
ore pieces. Prior to this operation, cores have
een impregnated, baked, cut, etched, and tested
second time.

Connecting tap leads from winding to tapchanger studs. On opposite side of assembly line, terminals are brazed to low voltage leads. Previous operations included applying adhesive to core faces, banding core pieces, and attaching frames.

fter bushings have been installed, the tanks filled
ith oil, and the transformers vacuum treated to
emove any entrapped air from the oil or wind-
ngs, final electrical tests are made.

(*Continued from page 52A*)

Fluorescent Lamp Ballasts. Two new publications on fluorescent lamp ballasts have been announced as available from the General Electric Company, Schenectady 5, N.Y. The first, a 20-page booklet, *GEA-5731*, explains how a fluorescent lamp works and the part the ballast plays in its operation; the second publication, *GEA-5672*, deals with the company's new system of "sound-rating" its ballasts.

Switch and Bus Insulators. Engineering specifications, cross-section and contour drawings, dimensions, and stacking data for Victor Switch and Bus Insulators are included in their bulletin number *5*, available from Victor Insulators, Inc., Victor, N.Y.

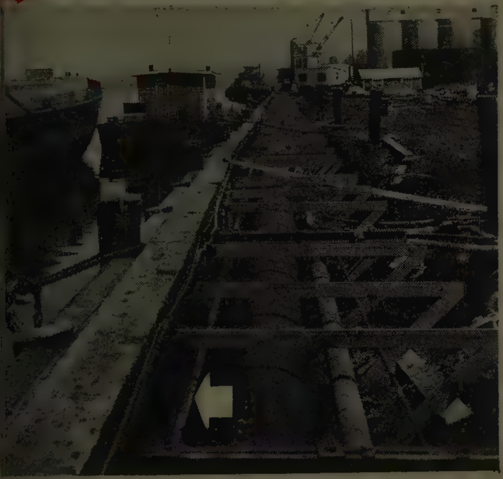
Nickel Alloyed Cast Irons. Engineering properties and applications of eight types of austenitic nickel alloy cast irons are described in a 36-page bulletin available from The International Nickel Company, Inc., Department *EZ*, 67 Wall Street, New York 5, N. Y.

Sturtevant Catalogue. Westinghouse Sturtevant has just published a 16-gage catalogue, *B-5164*, describing their air-conditioning equipment. Write Department T, Sturtevant Division, Westinghouse Electric Corporation, Hyde Park, Boston 36, Mass., for copies of the catalogue.

Maze of conduit carries Okolite-Okoprene control and power wiring from control panel to Kamyr Pulp Drying Machine. A major portion of the equipment in the motor generator sub-station is also controlled from this switchboard.

Motor generator room, showing 2300 entrance breakers, 550-volt distribution breakers, motor generator set and electronic speed regulator cubicles. All of these, both a-c and d-c, are fed by Okolite-Okoprene cable.

Okolite-Okoprene self-supporting aerial cables distribute power to transformer sub-stations from the Power House. "Stormsafe" aerial cable eliminates congestion, reduces clearance problems, and provides triple economy of quick installation, low maintenance costs and better voltage regulation.



why it pays to use OKOLITE-OKOPRENE CABLES *throughout* THE JOB

The Story of an Okolite-Okoprene Installation at a Large Southern Pulp & Paper Mill

MORE and more electrical engineers are specifying OKOLITE-OKOPRENE cables for complete installations. For when every electrical circuit on a job is OKOLITE-OKOPRENE, the degree of circuit security on that job is unequalled.

OKOLITE-OKOPRENE is especially suitable for complete installations because of its versatility. Highly resistant to every element which attacks cable, OKOLITE-OKOPRENE is used in wet, dry, hot or cold locations—exposed to weather or sunlight—underground or in conduit.

For instance, a large pulp manufacturer made extensive use of OKOLITE-OKOPRENE in installing a Kamyr Pulp Drying Machine. Power and control circuits, leads for the battery of synchronized generators and motors and circuit breakers, self-supporting aerial cable from sub-stations to the Power House — even push-button stations and the lighting system were OKOLITE-OKOPRENE.

The Company engineers selected OKOLITE-OKOPRENE throughout this job because of the necessity of keeping the Kamyr Machine in continuous operation. Resistant to moisture, heat, sunlight, oils, acids, ozone and chemicals, OKOLITE-OKOPRENE is the most economical and reliable way of supplying electrical power to key operations. The Okonite Company, Passaic, N. J.

THE BEST CABLE IS YOUR BEST POLICY

OKONITE PASSAIC, N.J.

OKONITE

OKONITE SINCE 1878 insulated wires and cables

Alduti INTERRUPTER SWITCHE

① Where Horn Gap Switches Are Inadequate

because horn gaps cannot, under all conditions, safely break magnetizing or charging currents; nor can they interrupt load currents

② Where Circuit Breakers Are Too Expensive

for non-automatic switching and short circuit protection

ALDUTI INTERRUPTER SWITCHES

offer a proved and economical solution to such application problems.

Ten years of operating experience in thousands of installations, and many field trials under severe test conditions, have demonstrated the ability of these Interrupter Switches to — safely and repeatedly —

- Sectionalize either radial or loop distribution and subtransmission circuits, under either load or charging current conditions . . .
- Switch load and magnetizing currents of transformer banks . . .
- Switch charging currents of capacitor banks.

And because there is NO EXTERNAL ARCING during the operation of Alduti Interrupter Switches: they need not be mounted horizontally upright, but can be mounted vertically, o underhung; hook stick operation can be employed where economy dictates; and phase spacings can be reduced to 18 inches for the 7,500-volt and 33 inches for the 34,500-vol switches. Hence structures can be smaller, connections simpler, and construction cost can be reduced below that of installing horn gap switches.

Also, Alduti Interrupter Switches can be metal clad, thus providing—even for subtransmission applications — enclosed "packaged-type" switches, thereby permitting the complete enclosure of all components of a substation.

When combined with S&C Power Fuses, Aldut Fused Interrupters also provide short circui protection with fault current interrupting ability up to 40,000 amperes asymmetrical, thu making possible the elimination of expensiv circuit breakers where automatic switching i not required.

Alduti Interrupter Switches are supplied in these ratings:

Volts	Continuous Amperes	Interrupting Amperes, Nominal
For hook stick or group operation		
7500 & 15000	400, 600, 1200	400, 600
For group operation only		
23000 & 34500	600	600

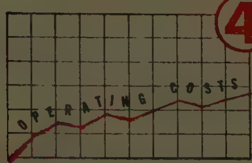
S&C ELECTRIC COMPANY

Formerly SCHWEITZER & CONRAD, INC. In Canada, Powerlite Devices, Limited, Toron

give you Great Advantages:

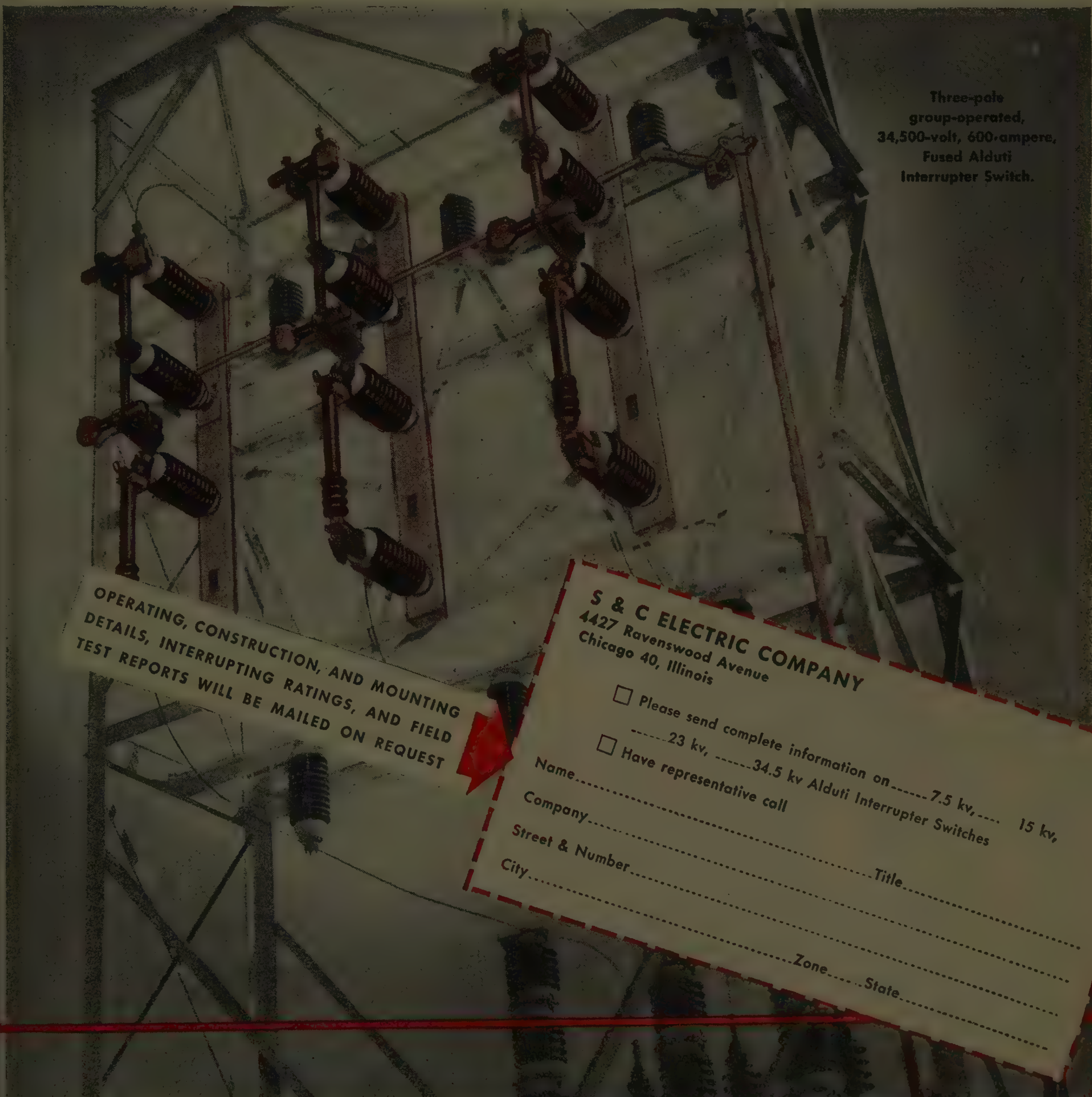
3 Where Structure Design Is Restricted

because horn gap switches can be mounted only in the horizontal upright position, and need wide phase spacings



4 Where Switching Sequences Are Complicated And Costly

because multiple operations—involving breakers, disconnects, and operating personnel— are required to isolate equipment or sectionalize circuits



BURNDY-BUILT

to do an important job

BETTER

special bus shapes . . .

We are in excellent shape to answer your needs. We've got T-connectors, couplers, bus supports, expansion joints. What's more, we've got them for channel, angle and square shape bus. Too, lots of utilities ask us to develop connectors for these special applications. We do it promptly, efficiently. Our engineering department is yours—for the asking. Our Representative too. Call him in on your next problem.

Oval recesses in bolt lugs and oval-shank bolts permit easy, single-wrench installation.

Strategic placement of *ribs* reinforces strength, provides wrap-around for better contact.

Strong bolts, properly placed for high pressure contact.

Internal *lips* guarantee accurate positioning on angle and channel bus.

BURNDY

connectors for special shapes

BURNDY, New York 54, N. Y.
Western Branch: Vernon 58, Calif.
Burndy Canada Ltd., Toronto 8, Ontario

Automobile tops, insulated with L·O·F Fiber·Glass against heat and cold, increase passenger comfort. Easy installation. Light weight. Won't deteriorate under normal conditions.

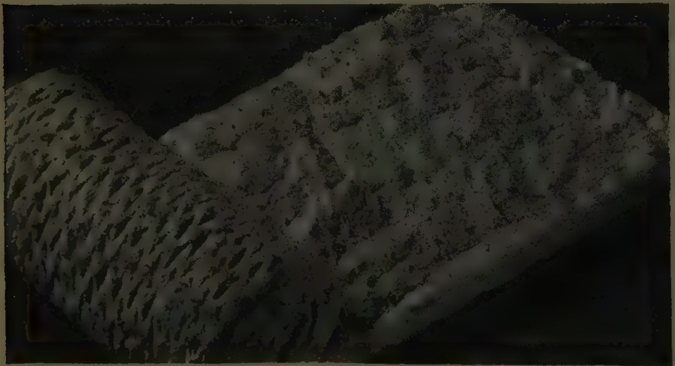
Automobile sound insulation a made-to-order job for L·O·F Fiber·Glass. Easy installation in doors, under the dash, on the fire wall, under the hood. Low moisture absorption, light weight.

Aircraft sound and thermal insulation. Get these advantages of L·O·F Fiber·Glass. Light weight (as low as .3 lb. per cu. ft.). High fire safety. Low moisture pickup. High sound-insulating efficiency.

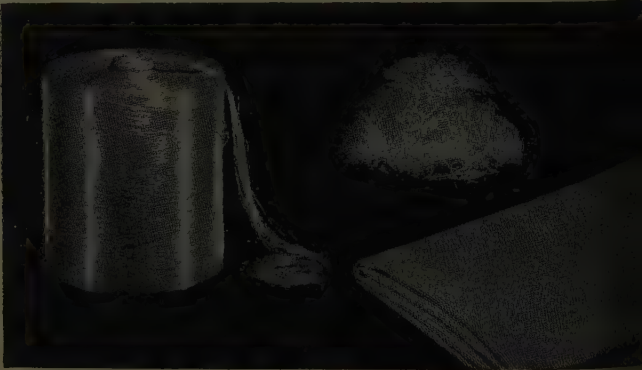
Proven glass technology plus now devoted to early production

Continuous Fiber Textile Yarn—150 series for many uses, such as electrical insulating tape, sleeving, cloth, roving, and paper reinforcement. Glass fibers have enormous tensile strength . . . 250 thousand pounds per square inch. High dielectric strength. Withstands temperatures up to 800°F.

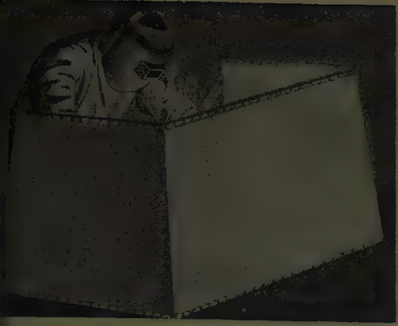
Super•Fine "B" Fiber—Splendid thermal- and sound-insulating qualities. Fiber diameter, .00012″. Temperature range -0°F. to plus 450°F. Standard roll widths, 18″, 24″, 36″, 72″, in 100′ and 200′ lengths. Other widths and lengths also available in a range of thicknesses and densities.



Super•Fine "AA" Fiber—primarily for aircraft insulation. Thickness, .5″ with density of .6 lb. per cu. ft. Fibers of incredibly small diameter—.00004″. With plastic binder to hold dimensional form. Roll widths, 36″, 72″, in 50′ standard length.



Roving, Chopped Strand and Textile Yarns—for reinforcing of plastics, paper, cloth and paper tape, etc. Enormous tensile strength. Won't shrink or stretch. Won't deteriorate under normal conditions. Versatile in application.



lustrial fabrics woven from Fiber·Glass
fine, safe, strong, rot- and mildew-
oof. Ideal applications are tarpaulins,
me shields, airplane cloth, reinforce-
nt for plastics.

Electric motors and generators insulated with L·O·F Fiber·Glass withstand heavy overloads. Appreciable space factor advantages! High dielectric strength.

Wire and cable can be served directly with L·O·F Fiber·Glass textile yarns using standard machines. Yarn also ideal for weaving tape, and braiding on wire and into sleeving.

ine, new facilities
of L·O·F FIBER·GLASS!

Aviation, automotive, textile and electrical industries first to benefit from new, high-quality source of supply being readied by Libbey•Owens•Ford

HERE IS headline news of *immediate* interest to key men of business and industry.

The resources and advanced technical glass knowledge of Libbey·Owens·Ford are being focused on a new product—L·O·F Fiber·Glass!

With fine, new facilities at Parkersburg, W. Va., placed to serve you quickly, glass technicians of proven ability and experience are getting set to produce top-quality Fiber·Glass products in volume. (See facing page for basic items to be produced. Note above and right for typical applications.)

Across the country, in 24 major cities, L·O·F offices are busy with preparations to give you help on specific uses.

If your company has already discovered the superior qualities of fibrous glass, investigate L·O·F now as a new volume source, worthy of your complete confidence.

If your company now buys other material for electrical insulation, thermal or acoustical insulation, or reinforcing for plastics or paper, L·O·F Fiber·Glass can offer a combination of advantages unmatched by such other materials. This is a chance to benefit from the glass technology and the high standard of quality which you have come to expect from L.O.F!

For technical data, or engineering consultation on Fiber·Glass uses in your business, call your local L·O·F office—or write, wire or phone Libbey·Owens·Ford, Dept. F·G 113, Nicholas Bldg., Toledo 3, Ohio.

Plastic reinforcing, as in this bread tote tray, presents many possibilities with L·O·F Fiber·Glass. Remarkable strength. Won't dent or lose shape. No discoloration of plastic material. Exceptionally long life.

Paper and paper tape reinforced with L·O·F Fiber·Glass can be raised in tensile strength to equal aluminum or even steel! Either Fiber·Glass textile yarns or scrim mesh are suitable. Investigate!

LOF FIBER·GLASS

LIBBEY·OWENS·FORD GLASS COMPANY

FIBER·GLASS DIVISION

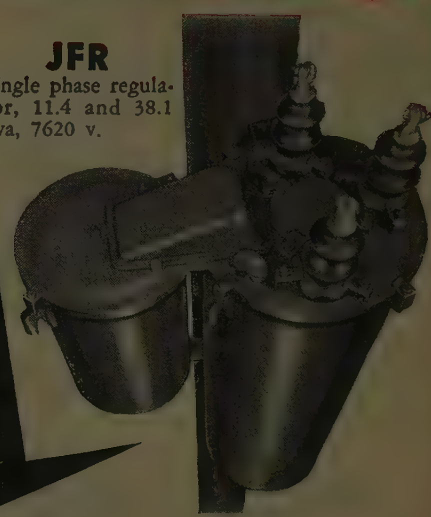
FIBER·GLASS

Large or Small-

AFR
Three phase regulator, sizes through 69 kv, 2500 kva.

DFR
Single phase regulator, sizes through 6900 v, 250 kva.

ALLIS-CHALMERS
5/8% STEP REGULATORS



JFR
Single phase regulator, 11.4 and 38.1 kva, 7620 v.

YOU GET THESE SAME plus features

7 QUALITY FEATURES YOU GET ON ALL ALLIS-CHALMERS REGULATORS

- ★ 5/8% steps
- ★ Close regulation (± 1 volt band)
- ★ Easy control adjustment. The same type of control used on all sizes
- ★ Close average voltage for all types of loads (maintained by voltage integrator)
- ★ Long life contacts of liberal design to withstand hundreds of thousands of operations
- ★ Tap changing drive mechanism with balanced spring action to eliminate shock . . . operates under oil for long trouble-free life
- ★ Unit construction to simplify maintenance

In addition to these important features, the single phase 5/8% step regulators require only 1/3 the exciting current of older types of single phase regulators. Low exciting current releases system capacity for useful loads.

You can count on Allis-Chalmers for regulation that helps boost capacity, increase revenue, and improve customer good will.

Get complete facts on Allis-Chalmers 5/8% step regulators from your nearby Allis-Chalmers district office, or write Allis-Chalmers, Milwaukee 1, Wisconsin.

A-3540

VICTOR THE VIGOROUS VOLT AGREES:
FULL VOLTAGE BRINGS MORE REVENUE

ALLIS-CHALMERS A-C

Originators of 5/8% Step Regulation

Instrument NEWS

ALL STAR PRODUCTS CUTS REJECTS TO ½ OF 1% WITH G-E GAUSS METER

"100% inspection for the first time and rejects cut to ½ of 1% are only two of the benefits we have been able to obtain through the use of our G-E gauss meters," reports All Star Products Company, Defiance, Ohio.

All Star Products, manufacturer of variable condensers and radio and television components, finds the General Electric gauss meter an essential item in test and inspection areas. The meter has enabled All Star to cut inspection costs by ⅓ and permitted a 20% material saving. With the simple-to-operate G-E gauss meter, readings are obtained in only 4 seconds. Because of this, All Star is able to do all of its testing along the production line.

Small and compact, the G-E gauss meter is easy-to-read, portable, and extremely rugged. This is why All Star supplies its field servicemen with gauss meters for inspecting television focus units.

For use with both d-c permanent magnets and electromagnets, the gauss meter can measure flux densities in extremely small magnet gaps—such as those of blocked relays, breakers, generators, and motors. It gives direct readings of unidirectional fluxes in gausses and can be supplied in a variety of ranges from 100 to 5000 gausses.

Training Reduced to ½ Hour With G-E Thickness Gage

Briggs Manufacturing Company, of Detroit, Michigan, builder of automobile bodies and Beautyware plumbing fixtures, reports, "We've found the G-E thickness gage so easy and simple to use that we've been able to reduce our operators' training time to ½ hour." At its Eight Mile Road Plant, where chromium and stainless-steel automotive accessories are manufactured, Briggs uses the G-E gage because it can be used by unskilled help after this short indoctrination course. This simplicity of operation is an important feature since a number of different persons must use the gage each day.

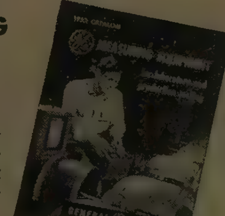
To protect the stainless-steel strips that go around car windows from damage during production, it is necessary to spray each part with a plastic film. Precise thickness limits for this plastic film have been set up and laboratory checks are made periodically on cold-rolled-steel test parts to assure that correct coating thickness is maintained.

The standard General Electric Type B thickness gage has a range of 0.10 mil to 100 mils. Other instruments of this type with ranges up to 300 mils can be furnished for the measurement of the thickness of any nonmagnetic material on a magnetic base.

1952 CATALOG

G-E Measuring Equipment

80 pages describing all of General Electric's testing and measuring devices. For free copy check GEC-1016 in coupon at right.



Paper Mill Refining Process Regulated with G-E Recorders

"Our General Electric CD-27 recording ammeters take the guesswork out of regulating the load on each of our refiners. We could not operate without them," reports Mr. G. F. Durand, Vice-president of Port Huron Sulphite and Paper Co. This Port Huron, Michigan company is an old and well-established maker of fine quality papers.

Port Huron's refiners are used to produce dense, hard, high quality light weight papers. The refiners are hooked up in series and the paper stock being processed flows from one to the other. The quality of the paper produced depends upon uniformly holding the prescribed load at which each refiner is run. By using the G-E recording ammeters to record the load on each refiner motor, Port Huron finds that periodical inspection and minor adjustment is all that is necessary to maintain correct and uniform paper stock treatment.

Recorder Measures 11 Quantities

Besides recording amperes, the G-E Type CD recorder can also measure volts, single- and polyphase watts, power factor, frequency, and vars. Models also can be supplied for measurement of d-c millivolts, milliamperes, and microamperes. Most ratings have an accuracy of plus or minus 1 per cent of full scale.

SECTION C 602-220, GENERAL ELECTRIC
SCHENECTADY 5, N. Y.

Please send me the following bulletins:
Indicate:

√ for reference only
X for planning on immediate project

- ☐ Type B thickness gage (GEC-319)
- ☐ Gauss Meter (GEC-238)
- ☐ CD recorders (GEC-216)
- ☐ 1952 Catalog (GEC-1016)

NAME.................................

COMPANY.................................

STREET.................................

CITY....................ZONE........STATE.......

GENERAL ELECTRIC

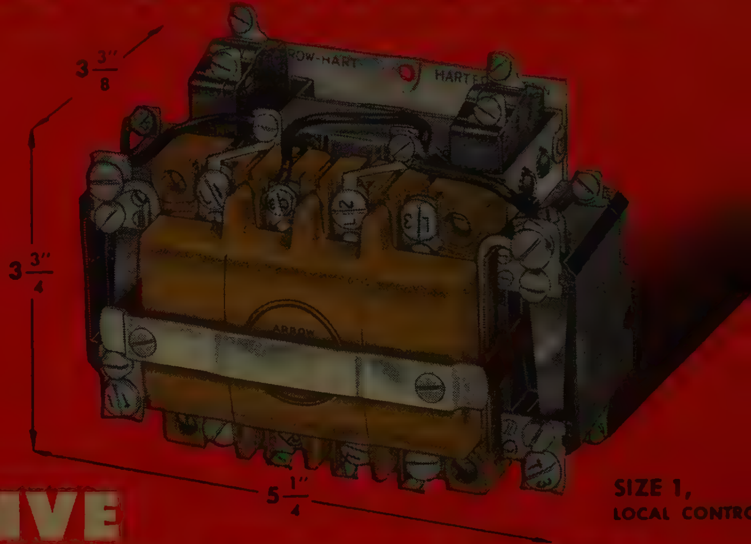
GREATER ELECTRICAL AVAILABILITY YOURS WITH

TYPE "RA" RIGHT ANGLE

ADVANCED DESIGN

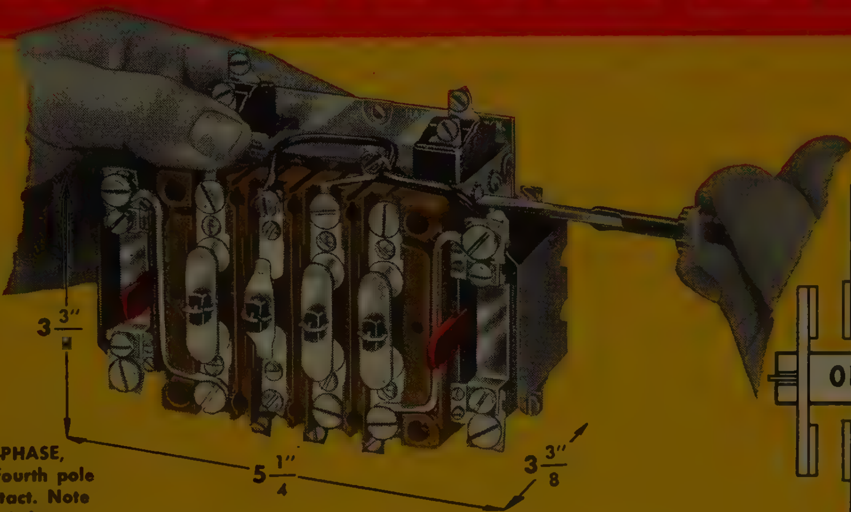
MOTOR CONTROLS

- JUST ½ THE SIZE • ½ THE WEIGHT
- BETTER PERFORMANCE
- 55% GREATER ARC RESISTANCE
- 30% SAVINGS IN INSTALLATION
- EASY TO WIRE AND TO INSPECT
- AVAILABLE IN SIZES 0, 1, 2, 3 and 4 IN NEMA Enclosure Types I, IV, V, VII, IX

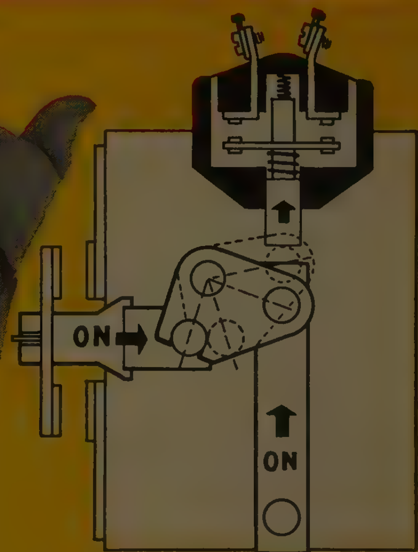


SIZE 1, LOCAL CONTRO

PLUS EXCLUSIVE ELECTRICAL INTERLOCK



SIZE 1,
REMOTE CONTROL, Standard 3-PHASE, employing fourth pole holding contact. Note auxiliary switches.



Schematic pictures "RA" mechanism trip arm that automatically energizes interlock switch.

NO OTHER STARTER PROVIDES THIS VERSATILITY

Arrow-Hart's "RA", right angle, balanced mechanism with bellcrank fulcrum assures simple and positive force to operate the A-H auxiliary switch or switches. JUST TWO SCREWS and a completely enclosed electrical holding interlock switch provide dependable operation of numerous interlocking device combinations or signal lights. Men confronted with adding more circuits to serve more needs in restricted space have accepted and are benefiting from the many outstanding features of the A-H Type "RA" line of motor controls. Buy an Arrow-Hart starter today and see for yourself.

BUY WITH CONFIDENCE PROFIT BY PERFORMANCE

THE ARROW-HART & HEGEMAN ELECTRIC CO., HARTFORD, CONN., U. S. A.

ELECTRICAL CONTROLS

ARROW AH HART

ESTABLISHED IN 1890

SELENIUM RECTIFIERS • PHOTO-ELECTRIC CELLS

FOR UNSURPASSED PERFORMANCE

MINIATURE RECTIFIERS

130 Volts R.M.S.

Peak Inverse Volts: 380

FOR ELECTRONIC APPLICATIONS UP TO 1,000 MILLIAMPERES

As easily Installed as a Resistor or Condenser

ONLY 2 SOLDERING OPERATIONS REQUIRED

Approximate Voltage Drop: 5 volts

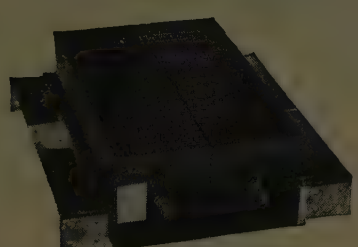
RATINGS AVAILABLE

Type No.	RS65	RS75	RS100	RS150	RS200	RS250
Current (ma)	65	75	100	150	200	250

Type No.	RS300	RS350	RS400	RS500	RS1000
Current (ma)	300	350	400	500	1000

SEND FOR TECHNICAL AND DESCRIPTIVE BULLETIN NO. IS-1249

POWER RECTIFIERS



RATINGS TO 250 KW

EFFICIENCY TO 87% — POWER FACTOR 95%

Suitable for Oil Immersion

FOR ELECTROPLATING, BATTERY CHARGING, ELEVATOR AND AIRCRAFT POWER SUPPLY UNITS, ETC.

PARTIAL LIST OF POWER RECTIFIERS

TYPE NO.	DC VOLTS	DC AMPS	SIZE PLATE
D507	0—15	0.5	1¼" Sq.
D510	0—15	3.0	3" Sq.
D513	0—15	14.0	6¼" x 7¼"
D517	15—30	3.0	3" Sq.
D520	15—30	14.0	6¼" x 7¼"
D521	95	5.0	4⅜" Sq.

WRITE FOR BULLETINS C-349 and C-848.

HIGH VOLTAGE RECTIFIERS

CARTRIDGE TYPE

RATINGS TO 25 KV AND 75 MA.

In half-wave, voltage doubler or bridge circuits

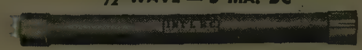
From ¼" to 1¼" O.D. or built to your specifications

TYPICAL APPLICATIONS

BIAS SUPPLIES
CONDENSER TESTING
CATHODE RAY TUBES
ELECTRON MULTIPLIERS
ELECTROSTATIC PROCESSES
GEIGER COUNTERS
INVERSE PEAK SUPPRESSORS
PHOTOFLASH POWER SUPPLIES
TELEVISION CIRCUITS

TYPE V-HF SERIES

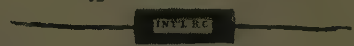
½ WAVE — 5 MA. DC



DC OUTPUT VOLTAGE	RECTIFIER PART NO.	DC OUTPUT VOLTAGE	RECTIFIER PART NO.
20	V1HF	800	V40HF
40	V2HF	1000	V50HF
60	V3HF	1500	V75HF
80	V4HF	2000	V100HF
100	V5HF	2500	V125HF
200	V10HF	3000	V150HF
400	V20HF	3500	V175HF
600	V30HF	4000	V200HF

TYPE Y-HP SERIES

½ WAVE — 11 MA. DC



DC OUTPUT VOLTAGE	RECTIFIER PART NO.	DC OUTPUT VOLTAGE	RECTIFIER PART NO.
20	Y1HP	800	Y40HP
40	Y2HP	1000	Y50HP
60	Y3HP	1500	Y75HP
80	Y4HP	2000	Y100HP
100	Y5HP	2500	Y125HP
200	Y10HP	3000	Y150HP
400	Y20HP	3500	Y175HP
600	Y30HP	4000	Y200HP

SEND FOR BULLETIN HVR-850

Unmounted cells available

DP5—Hermetically Sealed (front view)

PHOTO-ELECTRIC CELLS

SELF-GENERATING TYPE

LONG LIFE

STABLE CHARACTERISTICS

Output up to 600 microamperes at 100 foot-candles illumination and 100 ohms external resistance.

WRITE FOR BULLETINS PC-649, PPC-250, HPC-450

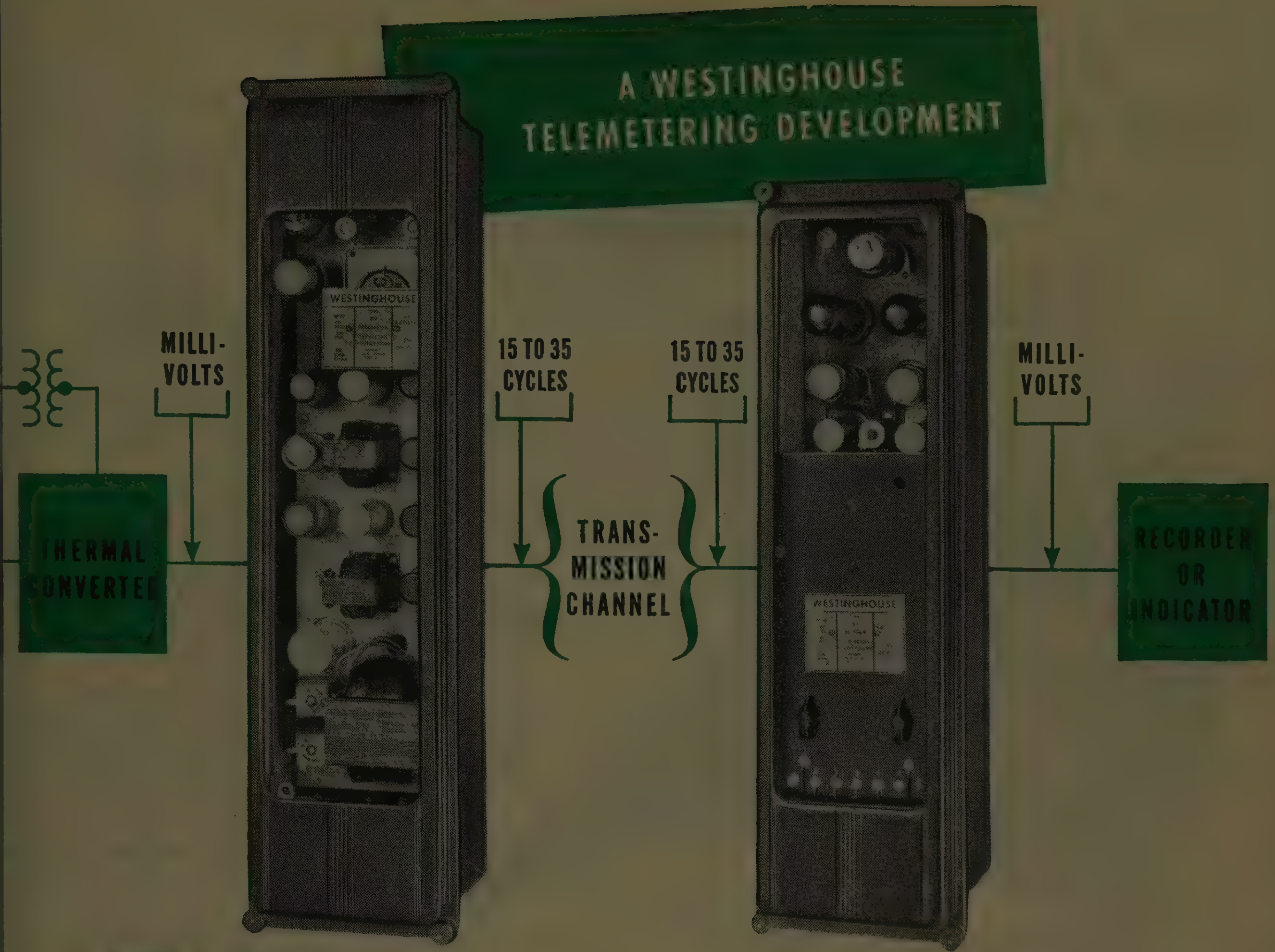
INQUIRIES ON YOUR APPLICATIONS INVITED • PROMPT DELIVERY

Subscription to Bi-monthly Technical Bulletin, "Rectifier News" if requested on company letterhead.

INTERNATIONAL RECTIFIER CORPORATION

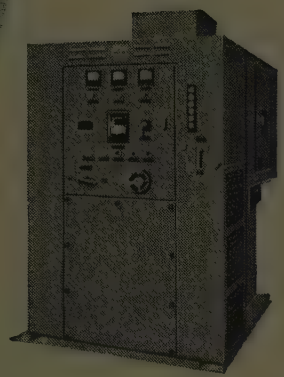
6809 SOUTH VICTORIA AVENUE • LOS ANGELES 43 • CALIFORNIA

REPRESENTATIVES IN PRINCIPAL CITIES • CONSULT YOUR LOCAL TELEPHONE DIRECTORY


A WESTINGHOUSE
TELEMETERING DEVELOPMENT
MILLI-
VOLTS
THERMAL
CONVERTER
15 TO 35
CYCLES
TRANS-
MISSION
CHANNEL
15 TO 35
CYCLES
MILLI-
VOLTS
RECORDER
OR
INDICATOR
WESTINGHOUSE

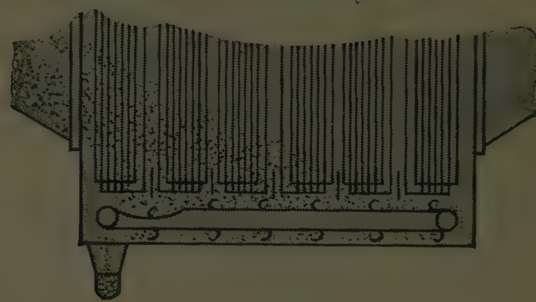
Let's be practical about precipitators

1



This Koppers "packaged" mechanical or vacuum tube power pack is not restricted to an area near the precipitator. It can easily be installed in any convenient place in the plant. Result: Compact designs! More flexibility!

2



This Koppers exclusive—the bottom drag scraper—provides continuous dust removal. Cumbersome hoppers are eliminated and dust handling is simplified. Result: Lower operating costs! Less space requirement!

Here are two ways Koppers engineers simplify precipitator operation for you!

PERFORMANCE GUARANTEED!

Koppers engineers protect your investment in an electrostatic precipitator by guaranteeing both the recovery or gas-cleaning *efficiency* and the *residual content* left in the gas after cleaning. Koppers-Elex electrostatic precipitators are designed, engineered, fabricated, erected and guaranteed *under one contract* by Koppers Company, Inc.

IN ADDITION to high efficiency, Koppers concentrates on the practical aspects of electrostatic precipitator design. Shown above are just two of the many practical features which simplify operation.

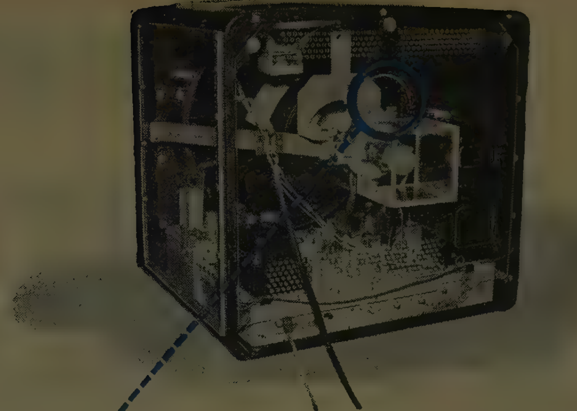
Besides these compact power packs and the continuous dust removal features, Koppers-Elex electrostatic precipitators may be of the multiple-chamber type. This means one chamber may be shut down for inspection or maintenance without stopping the gas-cleaning action. The dirty gas is simply diverted through other chambers where cleaning continues.

Because rapping is *sectionalized*, re-entrainment is minimized. And because successive collection fields can be separately *energized*, maximum voltage can be applied to each field—with higher gas-cleaning efficiency resulting. Pressure drops are negligible.

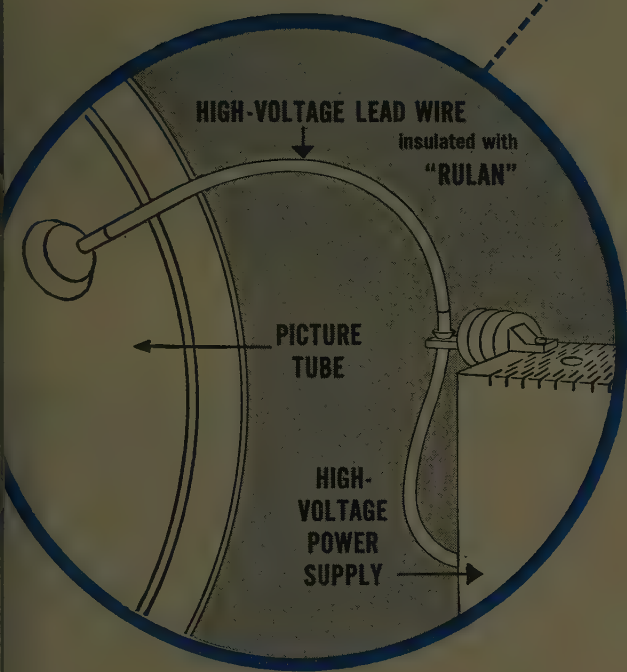
IF YOU HAVE A GAS-CLEANING PROBLEM, write and outline the details for us to review. There is no obligation. Just address your letter to: KOPPERS COMPANY, INC., *Precipitator Dept.*, 332 Scott Street, Baltimore 3, Maryland.

KOPPERS ®

Koppers-Elex ELECTROSTATIC PRECIPITATORS



Dielectric strength of Du Pont "Rulan"



Sketch shows high-voltage wire insulated with "Rulan" connected to kinescope in RCA Victor receiver. Extruded insulation of "Rulan" is only 45 mils thick for 10 kv, 67 mils for 20 kv, and 93 mils for 40 kv.

Wire manufactured by
Anaconda Wire & Cable Company,
New York, N. Y.

permits smaller cable in RCA Victor TV receiver; flame-resistance increases safety

This high-voltage DC lead wire insulated with Du Pont "Rulan"* flame-retardant plastic is a space-saver in RCA Victor television receivers. The high dielectric strength of "Rulan" permits a thinner insulating jacket for the cable. The jacket on a 10,000-volt lead is thin as a soda straw!

The insulation efficiency of "Rulan" is shown by its high resistance to corona in these TV leads. The dielectric constant is 2.7 and the power factor is 0.002—both constant over a wide range of frequencies. "Rulan" is non-tracking. And—important for safety—"Rulan" is flame-resistant and will not support combustion.

You'll be seeing more and more of this tough, flexible insulating plastic. "Rulan" can be used with no sacrifice of efficiency at temperatures as low as -76° F. and has very low water-absorption (only 0.02% by A.S.T.M. test). Excellent for neon sign cable, high-voltage hook-up wire, multi-conductor cable, signal control wire, high-voltage street-lighting cable, and many other applications where a flame-resistant insulation is needed.

Because "Rulan" contains no plasticizer, it is useful in non-migrating jackets. It can be extruded onto wire at high speeds and can be injection-molded.

Demand for Du Pont "Rulan" currently exceeds supply. However, we suggest you investigate the versatile properties of "Rulan" for future application. For more information write:

*TRADE-MARK

E. I. du Pont de Nemours & Co. (Inc.),
Polychemicals Dept., District Offices:
350 Fifth Avenue, New York 1, New York
7 S. Dearborn St., Chicago 3, Illinois
845 E. 60th St., Los Angeles 1, California

DU PONT
REG. U. S. PAT. OFF.
BETTER THINGS FOR BETTER LIVING
...THROUGH CHEMISTRY

Polychemicals
DEPARTMENT
PLASTICS • CHEMICALS

ALLIS-CHALMERS

PUT THE "Heat"

NIT SUBSTATIONS

N PRODUCTION!

YOU CAN INCREASE the production of your plant without adding production equipment or hiring more help . . . just eliminate undervoltage. Motors, lights, heating units—all electrical equipment gives top performance only when operated at full voltage.

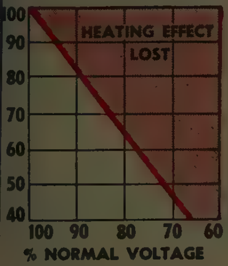
Paint baking or drying operations take longer when voltage drops. For example, a 10% drop reduces heating effect of infra-red lamps 19% . . . slows production. One paint drying operation required 63% more time when voltage dropped 10%.

A major cause of undervoltage is long, heavily loaded 480 volt feeders. Install Allis-Chalmers LCS Unit Substations at load centers and eliminate excessive line drop by shortening low voltage cables. Performance of all electrical equipment will improve . . . and personnel efficiency will increase because of better illumination from existing lighting fixtures.

You can count on the cooperation of experienced Allis-Chalmers substation engineers in working out your distribution system. Allis-Chalmers LCS Load Center Unit Substations are neat, compact, easy to install and provide protection to personnel. Get in touch with your A-C representative, or write Allis-Chalmers, Milwaukee 1, Wisconsin. A-3373

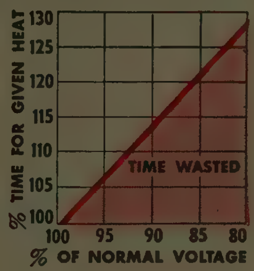
ALLIS-CHALMERS
LCS
LOAD CENTER
Unit Substations

HOW UNDERVOLTAGE WASTES MANHOURS . . . CUTS PRODUCTION

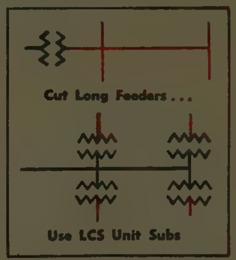


. OUTPUT from existing ...pment demands full voltage. Heat output of infra-red ...s (used for baking paint ...metal, drying coils of elec... apparatus and similar ...ications) drops with un...oltage. Output of resistance ...aces also drops off as the ...re of undervoltage.

PRODUCTION LOSSES RESULT from undervoltage. In one case a 10% drop in voltage cut the output of an infra-red drying oven from 1500 pounds per hour to 1275. Undervoltage means less work done each day . . . greater overhead for the work done, more manhours to be figured into every job.



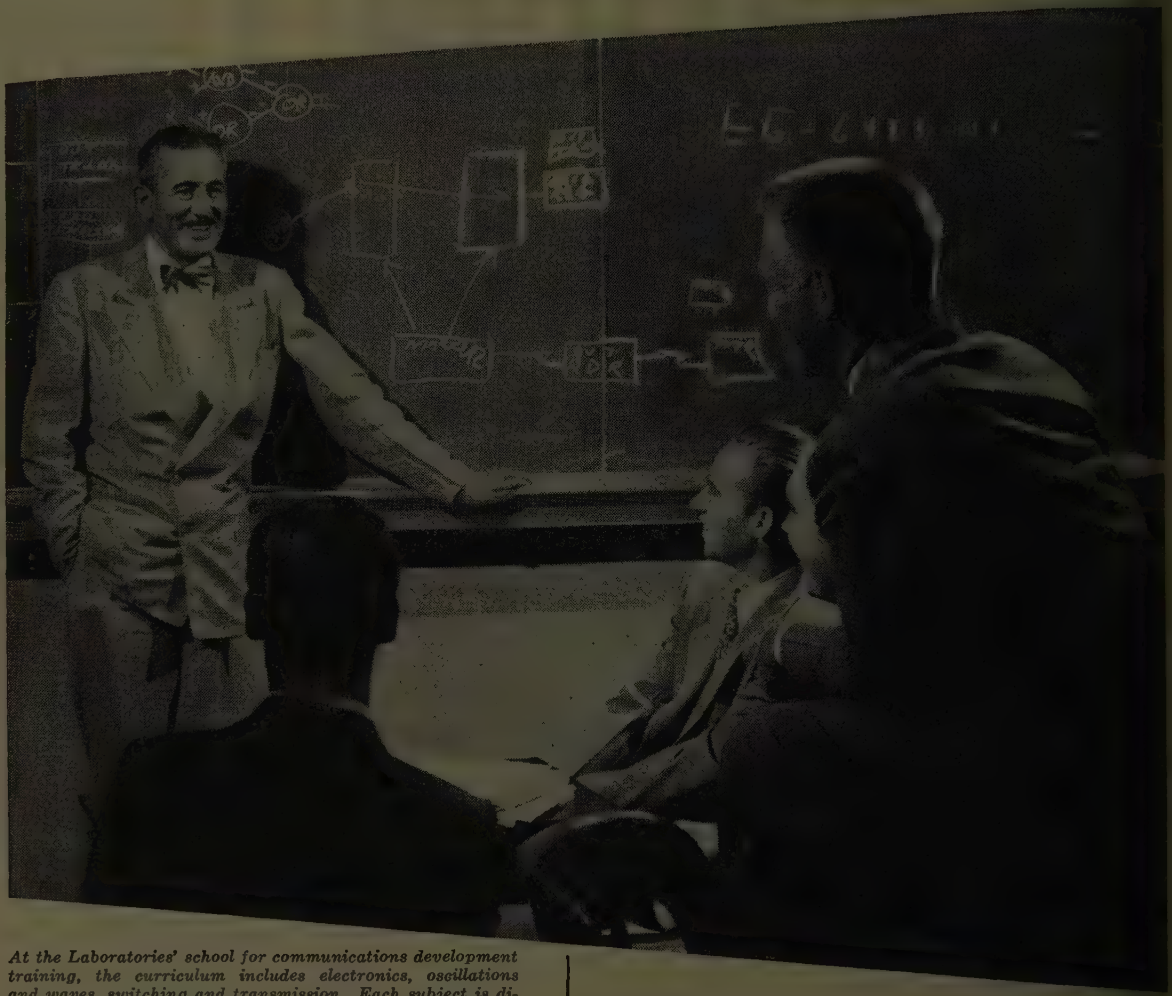
TIME IS WASTED when undervoltage is distributed to infrared bulbs and other heating devices. It takes longer to deliver the same amount of heat . . . longer to do a given job. In one plant, drying time for black painted sheet steel increased from 11 to 18 minutes by a 10% drop in voltage.



A MAJOR CAUSE OF UNDERVOLTAGE is voltage drop in secondary feeders. Long low voltage lines may prove inadequate as production schedules are stepped-up and new machines added. Install substations at load centers to cut feeder length, reduce voltage drop and increase production.

ALLIS-CHALMERS

They're headed for new frontiers



At the Laboratories' school for communications development training, the curriculum includes electronics, oscillations and waves, switching and transmission. Each subject is directly keyed to the latest fields of telephone research.

EACH year the Bell System selects hundreds of engineering graduates from technical schools, to find the answers to communications problems through the application of science and technology. A specifically qualified group joins Bell Laboratories to develop *tomorrow's* telephone system — also, in the present emergency, more powerful electronic devices for the armed services.

They come — thanks to the competence of our nation's educators—with an excellent grounding in fundamentals. To equip them still further, the Laboratories operate a school at graduate level for advanced communications.

The new men receive an intensive course in the latest theory and techniques. At the same time they take their places as members of the Technical Staff doing responsible work which, with their classroom instruction, reveals where they can make the most of their aptitudes.

More than ever America's future must depend on men and women who are trained to think far ahead in technology whether for tomorrow's telephones or national defense. By helping them, Bell Telephone Laboratories help make America's telephone system the world's best, help the armed forces keep our country strong.

BELL TELEPHONE LABORATORIES

Exploring and inventing, devising and perfecting, for continued improvements and economies in telephone service.

Underwriters approved as Type USE—Style RR for 600 Volts. First to be approved by Civil Aeronautics Administration as Type A insulation for airport wiring under Specification L-824.

A page from the note-book of Sylvania Research

Sylvania uses "demountable" picture tube in studying electron optics

damental research and development in tron optics at the Physics Laboratories ylvania Electric Products Inc. is mpanied by a high order of ingenuity in creation of test instruments.

or instance, a demountable system, wherein tron guns and electron gun components be changed rapidly, is used to rmine gun characteristics with such parameters as aperture diameter, trode spacings, potentials, etc. e of the characteristics that may be estigated in such a system are spot , electron beam diameter and shape, tron lens aberrations, and deflec- defocusing effects, etc. A com- e and systematic study of the tron optics of guns, including rnal components such as ion trap gnets, focusing coils, and deflection es, is necessary to determine ch gun type gives optimum per- mance for the particular use which it will be put.

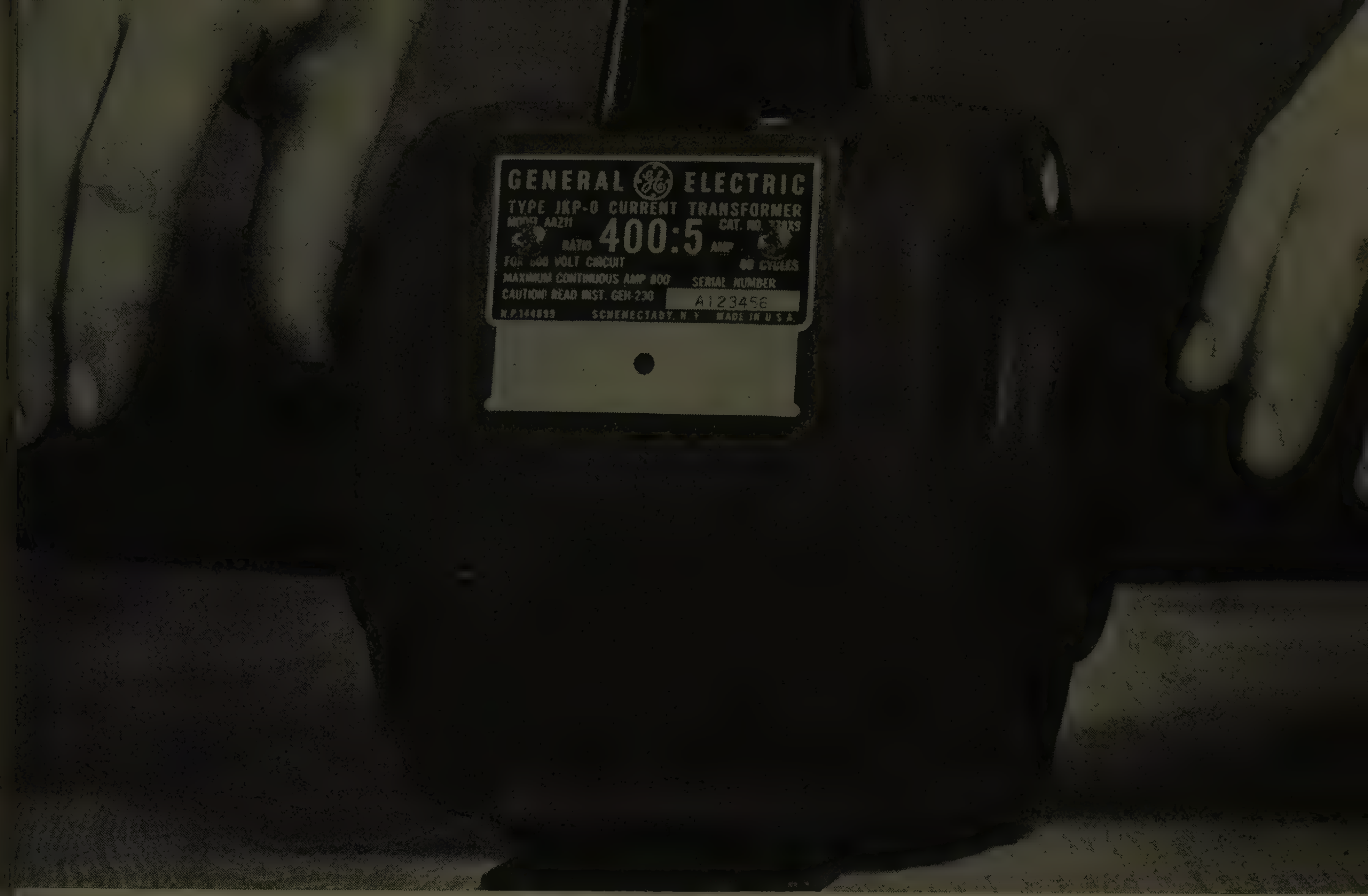
ylvania research and engineering ll phases of electronics is sic part of its production ubes and components for the ustry—an unending search better quality, better formance, better values.

A special deflection yoke being tested on Sylvania physics lab's demountable system. The focusing coil and electron gun are regular components.

SYLVANIA

vania Electric Products Inc., 1740 Broadway, New York 19, N. Y.

SION PICTURE TUBES; ELECTRONIC TEST EQUIPMENT; ELECTRONIC DEVICES; RADIO TUBES; FLUORESCENT TUBES, FIXTURES, SIGN TUBING, WIRING DEVICES; LIGHT BULBS; PHOTOLAMPS; TELEVISION SETS



New G-E indoor-outdoor current transformer helps reduce stock requirements—cut inventory costs

FOR USE INDOORS OR OUT, transformers can be mounted close together because secondary terminals are on top. This makes them especially suitable for use in small boxes. They can also be mounted directly on poles.

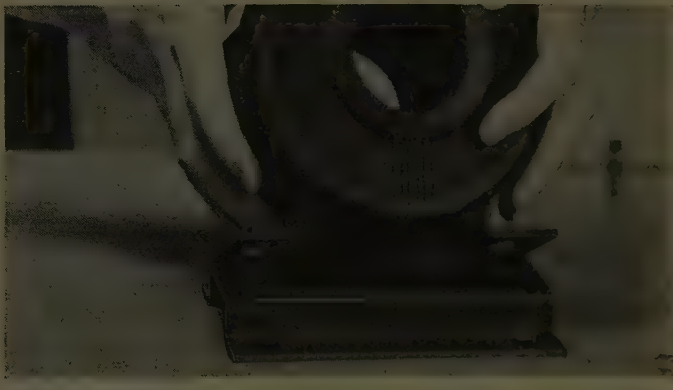
ONE BUTYL-MOLDED UNIT FOR FIVE APPLICATIONS. For the first time, you can buy a single current transformer that can be used for five different applications. General Electric's new *butyl-molded* Type JKP-0 transformer can be used on ordinary applications either indoors or out. It can also be used as a three-wire transformer . . . indoors or out. In addition, it is interchangeable with wound-type transformers to meet EEI specifications.

Result: reduced stock requirements and inventory costs.

New 600-volt Type JKP-0 transformer has primary ratings of 200-, 400-, and 600-amperes. For complete information, contact your local G-E representative or write Section 604-30 for Bulletin GED-1465. General Electric, Schenectady 5, N. Y.

GENERAL ELECTRIC

WHEN USED AS A THREE-WIRE TRANSFORMER, two conductors are passed through the window. Two-inch window allows easy insertion of full-sized primary cables for either indoor or outdoor installations.



WHEN MOUNTED ON ADAPTER PLATE, transformer meets the dimensional requirements of EEI specification MS2 . . . thus increasing its interchangeability and making possible another application of the single unit

Reducing Diet

FOR ELECTRONIC EQUIPMENT

Centralab parts cut down *size-space-weight* and *cost* of TV-FM-AM and military electronic gear

MINIATURE CONTROLS — You can rely on Centralab for the smallest in controls. For example, Centralab's Model 1 variable resistor . . . smaller than a dime — available in standard or Hi-Torque types — either type with or without a built-in, off-on switch. New Hi-Torque units hold exact settings under conditions of vibration or shock.

MINIATURE CAPACITORS — Centralab ceramic capacitors make tremendous savings in space — many of them are ⅕th and less the size of ordinary capacitors. They provide permanence never before achieved with old-fashioned paper or micas. Ceramic body provides imperviousness to moisture and ability to withstand temperatures generally encountered in electrical apparatus. Rely on Centralab ceramics for close tolerance, high accuracy, low power factors and temperature compensation as required.

PRINTED ELECTRONIC CIRCUITS . . . no other modern electronic development offers such tremendous space, weight, and cost saving advantages as Centralab Printed Electronic Circuits. They provide complete miniature units of widely diversified circuits—from single resistor plates to complete speech amplifiers. Centralab PEC's are available in a number of standard units — and where conditions warrant, numerous other circuit complements can be developed for quantity requirements.

MINIATURE SWITCHES — Centralab's new Series 20 and Series 30 miniature switches are designed to meet the modern trend toward *greatly reduced* size. Their extremely small size, plus availability of separate sections and index assemblies provide broad opportunity for design engineers and manufacturers. Available in multi-pole, multi-position, multi-section (phenolic or Steatite) units and in combinations with attached line switches and/or variable resistors.

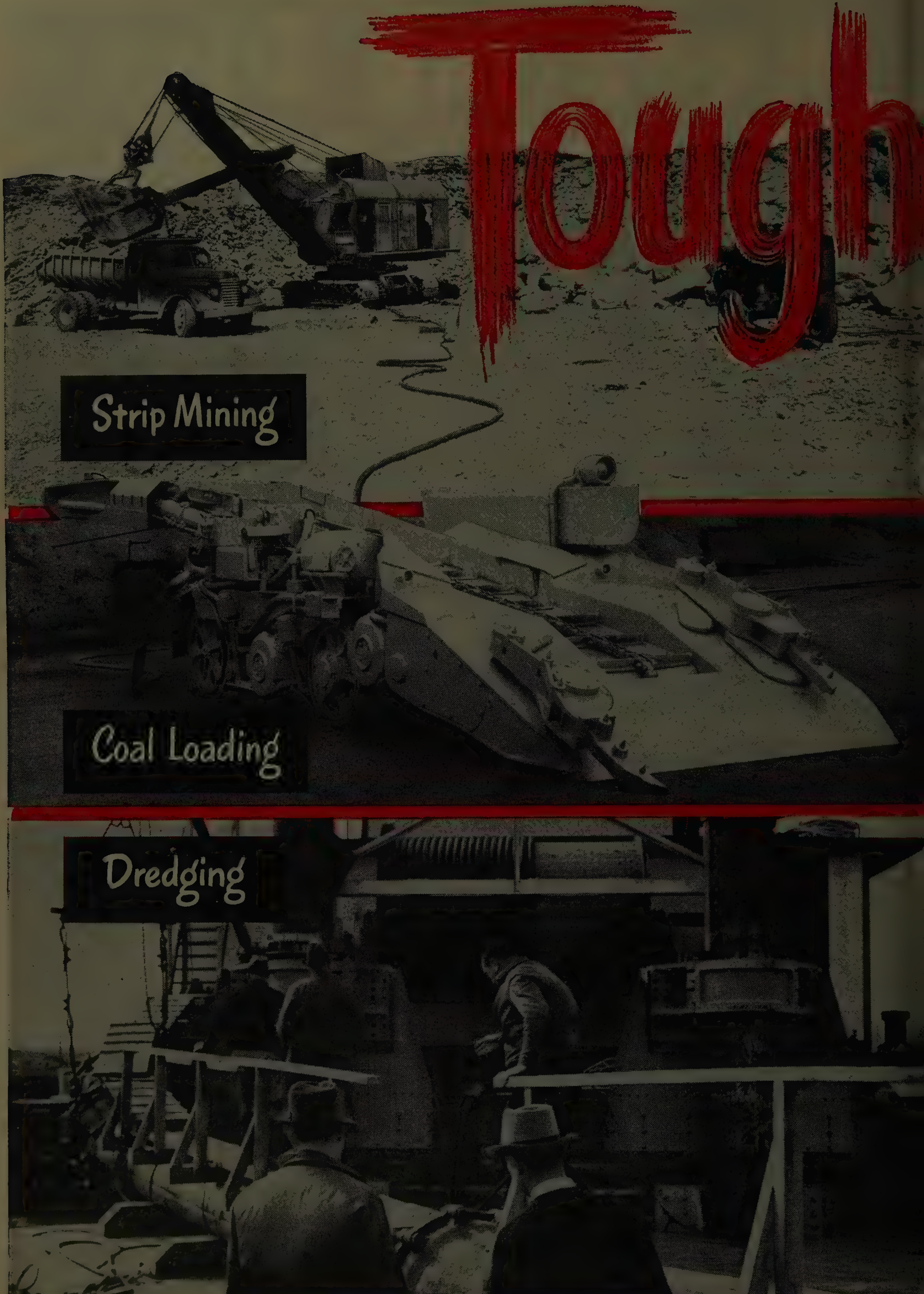
★ ★ ★ ★

Centralab offers electronic design engineers a complete line of miniature controls, switches, capacitors and printed electronic circuits in the *ratings needed* to help you *miniaturize* nearly all types of electronic equipment. You'll find Centralab an excellent source of supply for these miniature components — in standard models — or special adaptations. Technical literature and engineering consultation available. Write:

Centralab CRL ®

Division of Globe-Union Inc.

932 East Keefe Avenue • Milwaukee 1, Wisconsin


Tough
Strip Mining
Coal Loading
Dredging

jobs all...

but they're easy for

AMERCLAD*

***the heavy-duty electrical cable and cord**

You'll find U·S·S Amerclad down in the mines, where it's relentlessly coiled and uncoiled and dragged over rails and ties. You'll find it on railroads for general utility use under all types of conditions.

You'll find Amerclad delivering power to the shovels in quarries and strip mines. There, it's reeled in and out all day long and hauled over sharp rock.

You'll find Amerclad under water, too . . . it's used on dredges that need electrical cable that can withstand great abuse. Actually, there's an Amerclad Cable or Cord for just about any tough operating condition you can name.

Amerclad Cable and Cord is jacketed with tough, resilient Amerprene. This quality jacket resists moisture, sunlight, mineral oil, grease, flame. It will not propagate fire. And it meets the requirements of ASTM D752.

Amerclad Cable and Cord can be furnished with PS Shielding,† the conducting rubber tape that prevents corona discharge because it will not pull away from the insulation like metallic shielding.

For more information, get in touch with your nearest American Steel & Wire Company office.

†PS Shielding—an original development of American Steel & Wire Company.

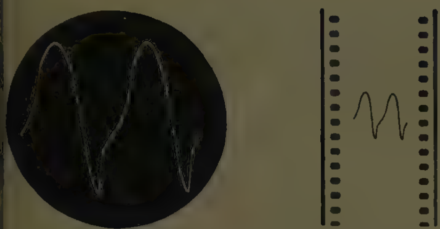
AMERICAN STEEL & WIRE COMPANY, GENERAL OFFICES: CLEVELAND, OHIO
COLUMBIA STEEL COMPANY, SAN FRANCISCO, PACIFIC COAST DISTRIBUTORS
TENNESSEE COAL, IRON & RAILROAD COMPANY, BIRMINGHAM, SOUTHERN DISTRIBUTORS
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

American Electrical Wire & Cable

USS

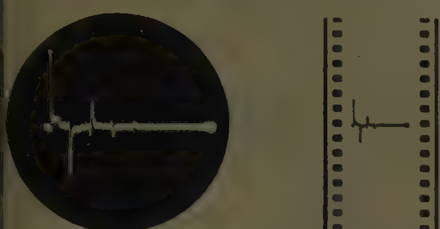
UNITED STATES STEEL

How much can you expect an oscilloscope camera to do?



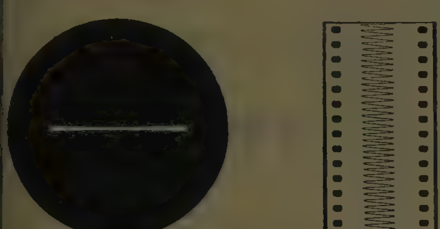
Scope Image | Film Recording

1. Single-frame photography of stationary patterns using a continuously running sweep.



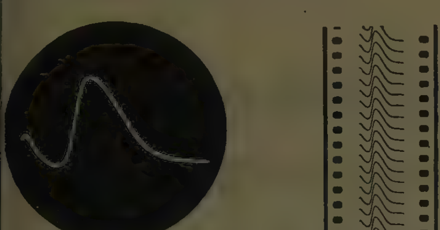
Scope Image | Film Recording

2. Single-frame photography of single transients using a single sweep.



Scope Image | Film Recording

3. Continuous-motion photography employing film motion as a time base.



Scope Image | Film Recording

4. Continuous-motion photography employing oscilloscope sweep as a time base.

FILM MOTION TIME BASE | FILM MOTION & SCOPE SWEEP

5. Continuous-motion photography employing combination of film motion and oscilloscope sweep as a time base.

It's only reasonable that you should expect the oscilloscope camera you buy to record what you see on an oscilloscope screen during any period. But can it be expected to do any more? We think so.

For example, did you know that the *Fairchild Oscillo-Record Camera*—our idea of the most versatile 35-millimeter oscilloscope camera now available—can GREATLY EXTEND THE USEFULNESS OF YOUR OSCILLOSCOPE?

As you know, many non-recurring phenomena occur too rapidly to permit adequate visual study. Others occur so slowly that continuity is lost. Sometimes you have combinations of very slow-speed phenomena and occasional high-speed transients. In any one of these cases, the Fairchild Oscillo-Record Camera will take over where your eye and the oscilloscope leave off.

This extremely versatile instrument is now being used daily by many hundreds of engineers in widely divergent fields. For an idea of what it can do for you, study the five scope images and recordings illustrated at left. Each solves a particular problem.

Oscillo-Record users especially like its:

CONTINUOUSLY VARIABLE SPEED CONTROL—1 in./min. to 3600 in./min.

TOP OF SCOPE MOUNTING that leaves controls easily accessible.

PROVISION FOR 3 LENGTHS OF FILM—100, 400, or 1000 feet.

For more data write *Fairchild Camera Instrument Corp., 88-06 Van Wyck Blvd., Jamaica 1, N. Y. Dept. 120-16E1.*

FAIRCHILD OSCILLO-RECORD CAMERA—1. camera, 2. periscope, 3. electronic control unit. *Available accessories* include external 400 and 1000 foot magazines, magazine adaptor and motor, universal mount for camera and periscope, binocular split-beam viewer.

VALUABLE RECORDS FOR IMMEDIATE EVALUATION

The Fairchild-Polaroid® Oscilloscope Camera produces a photographic print in a minute

Valuable but inexpensive oscillograms for immediate evaluation; automatic one-minute processing without a darkroom; a set up time of two minutes or less—they're just three of the many advantages that are yours when you use the Fairchild-Polaroid Oscilloscope Camera. Wherever individual exposures meet your recording requirements—where you'd like to have permanent records of the traces you're now sketching or carrying in your memory, this is the camera that can bring new speed, ease and economy to your job. Prints are 3¼x4¼ and each records two traces exactly one-half life size. Write today for details.

A minute after you've pulled the tab a finished print is ready for evaluation

FAIRCHILD
OSCILLOSCOPE RECORDING CAMERAS

Boost feeble input signals with Sensitrol® ultra-sensitive relays......

How many devices do *you* know of that use an amplifier to boost a feeble input signal up to where it will operate a relay? Most of them would be more reliable . . . more compact . . . more economical—if the amplifier could be omitted.

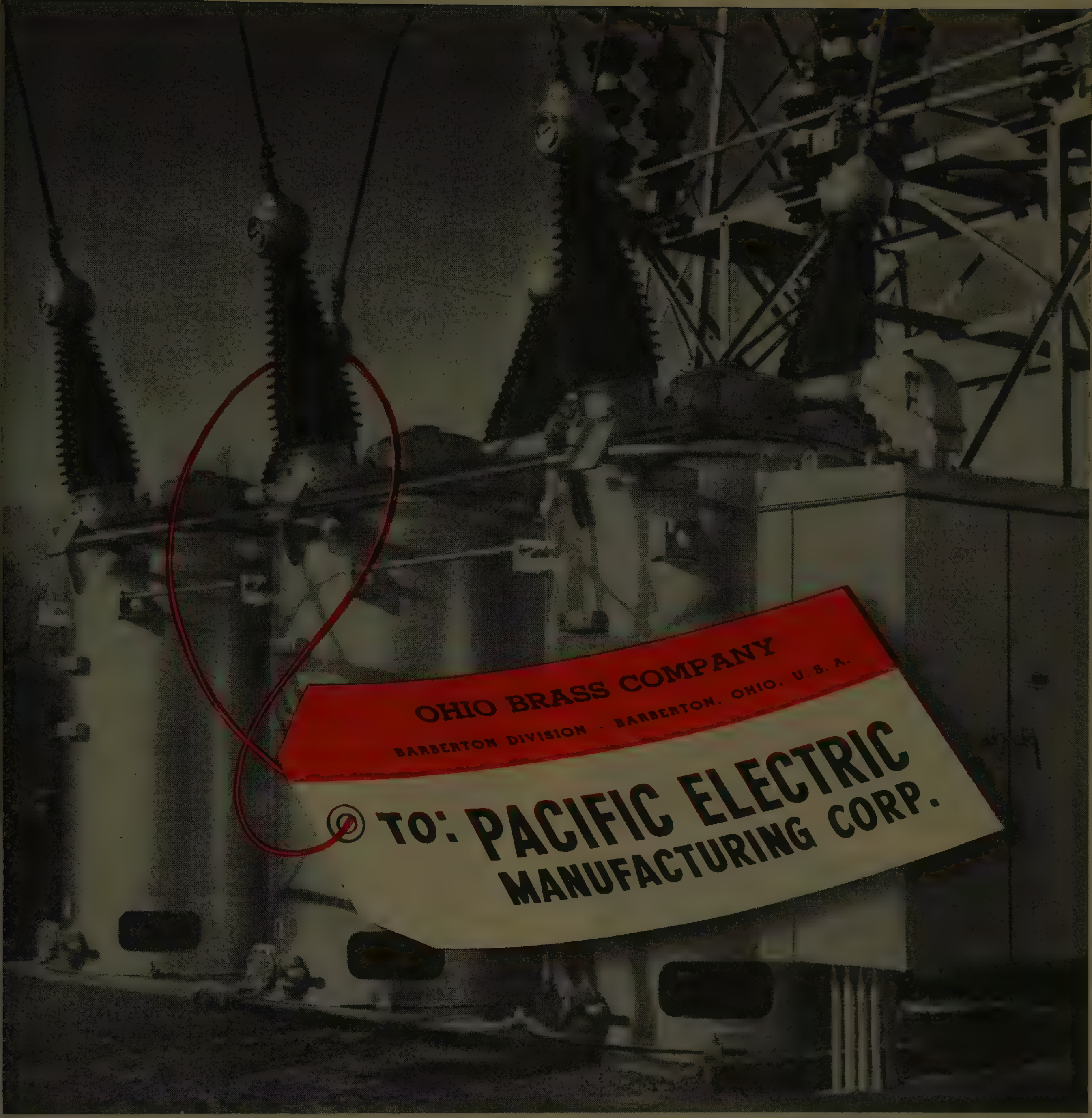
It can be omitted! For rugged Weston Sensitrol Relays operate reliably on input signals as slight as *1 millivolt* or *½ microampere,* handle substantial wattage *at 110 volts!* They require no power for excitation.

Engineering assistance is freely offered to help you adapt these Sensitrol Relays to present products, or any new problems you may have in mind. Simply consult your nearest Weston Representative, or write Weston Electrical Instrument Corporation, 590 Frelinghuysen Avenue, Newark 5, New Jersey . . . manufacturers of Weston and TAGliabue instruments.

A Type for Every Need

So sensitive that they operate direct on the output of a photo-electric cell or thermocouple, Sensitrol relays enable the instrument engineer to dispense with amplifiers, vacuum tubes and auxiliary power supplies. Single or double contacts, fixed or adjustable, manual or solenoid reset. Be sure you have a copy of Bulletin B-25-B, which gives detailed data on Sensitrol and other Weston relays.

WESTON *Instruments*



One of several 115-kv oil circuit breakers supplied to a large Western system by the Pacific Electric Mfg. Corporation. According to its builder . . . "each entrance bushing of this circuit breaker is mounted on an adapter flange which has a spherical-ring undersurface that rests upon a similar surface of the transformer-pocket flange. This greatly facilitates field installation of the bushings and contact structures attached to them because selective tightening of the flange bolts will shift the bottom of the bushing to any desired position. Other Pacific Electric features include closing by stored energy in motor-compressed springs, improved arc extinguishment," . . . And

Ohio Brass

MANSFIELD • OHIO

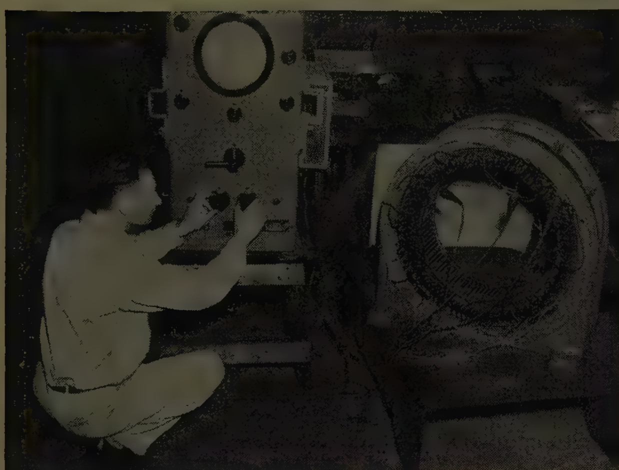
4147-H

O-B BUSHINGS

ONE OF THE FINEST COMPONENTS OF ANY CIRCUIT BREAKER

HOW THREE COMPANIES IMPROVED ELECTRICAL TESTING

G-E Winding Insulation Tester Now Used In All These Operations



SERVICE SHOP: "We are now able to test for insulation faults between coils and turns, as well as between coils and ground, and the Winding Insulation Tester is light enough to take on repair jobs in the field," reports the Test Dept., 153rd St. Shops of Consolidated Edison Co. New York, N. Y.

MOTOR MFG: "Our motors get a complete test on impedance, turn balance, and insulation . . . in a hurry . . . we test thousands of motors per week," says G-E refrigerator motor plant, Ft. Wayne, Indiana.

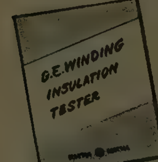
GENERATOR MFG: "The new tester picks up faults with only one connection. It is easy to operate and all testing can be done with the flip of a switch," says this large mid-western generator manufacturer.

General Electric's Winding Insulation Tester Will:

- Indicate shorts; stress insulation *between* coils, between turns, and between coils and ground.
- Simulate in-service voltage surges.
- Detect reversed coils and phases.

The Winding Insulation Tester performs most all required electrical tests, over a wide range of equipment rated up to 2000 hp, 2300 v. In some cases it has been used exclusively for routine production-line testing.

If you are looking for a way to increase the speed and effectiveness of your electrical testing, investigate the new G-E Winding Insulation Testers.



Write for bulletins GEC-794 & GEC-321 to:
General Electric Company, Sect. 687-82, Schenectady, N. Y.

You can put your confidence in—

GENERAL ELECTRIC

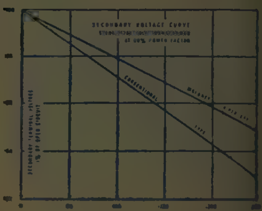
687-82

The inside story about

MOLONEY *HiperCore* DISTRIBUTION TRANSFORMERS

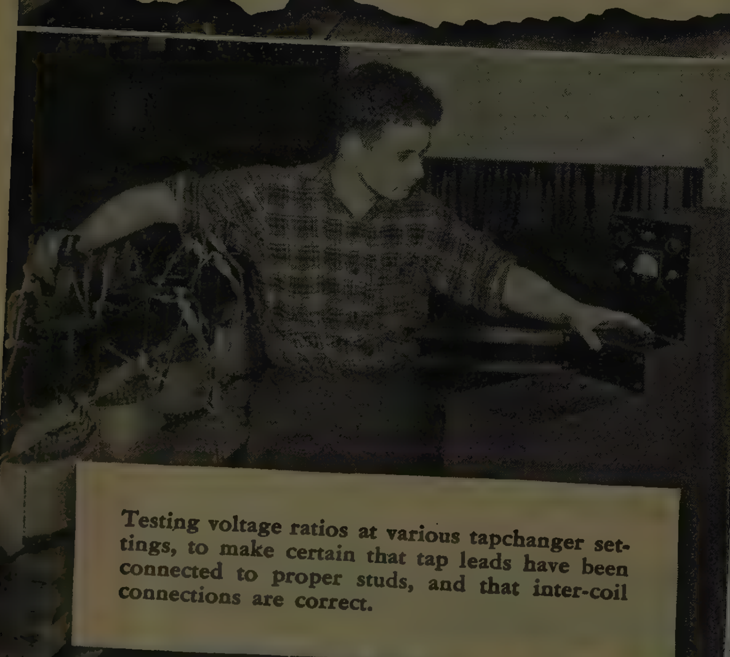
The inside story about Moloney HiperCore Transformers is centered around the material used in the cores. By using highly efficient oriented silicon steel it is possible to work the cores at higher flux densities than formerly. With the *total* flux requirements remaining practically unchanged, working the oriented steel at higher densities than practical with ordinary silicon steel, results in smaller cross-sectional areas of cores with a consequent reduction in weights.

The smaller cores permit the use of smaller windings, smaller tanks and less oil. This results in lighter weight and smaller transformers which are easier to install and handle generally, and take up less space on the poles. Reductions in size and weight have been made without sacrifice in all-around performance. In fact, HiperCore Transformer operating characteristics are better . . . voltage regulation has been improved . . . greater short-time overloads can be carried.

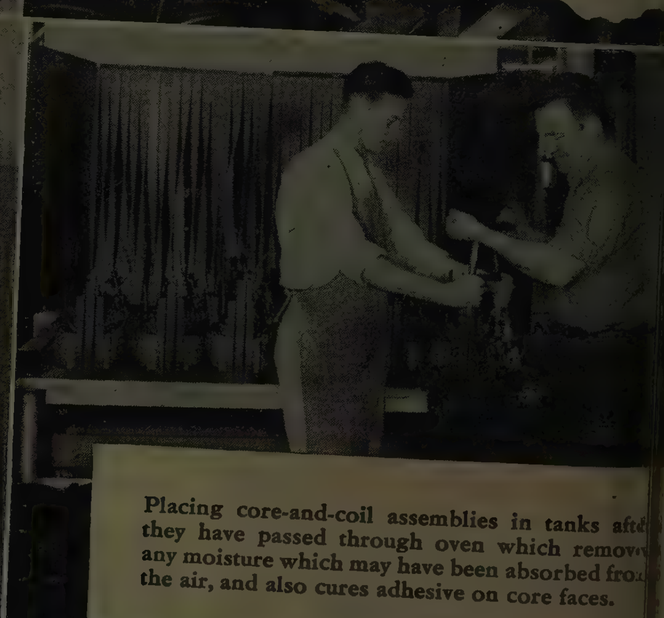


Illustrated are a few of the operations involved in the manufacture of HiperCore Transformers indicating the careful attention given to every detail in order to assure unexcelled on-the-job performance.

ME49-1-

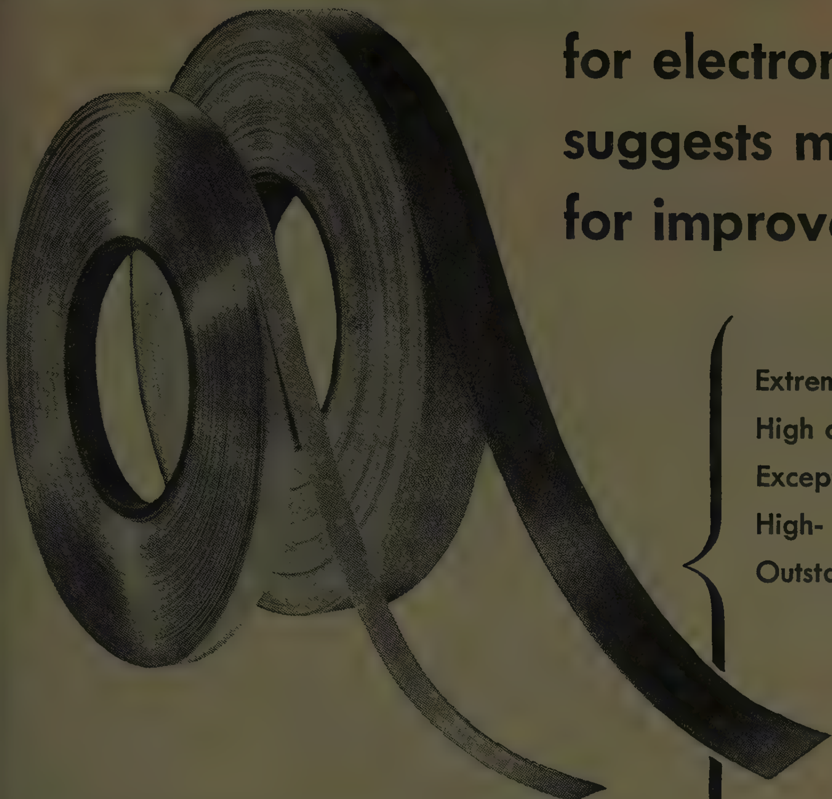


Testing voltage ratios at various tapchanger settings, to make certain that tap leads have been connected to proper studs, and that inter-coil connections are correct.



Placing core-and-coil assemblies in tanks after they have passed through oven which removes any moisture which may have been absorbed from the air, and also cures adhesive on core faces.

UNIQUE COMBINATION OF PROPERTIES



for electronic insulation . . . suggests many opportunities for improved design

- Extremely low loss characteristics
- High dielectric strength
- Exceptionally high arc resistance
- High- and low-temperature resistance
- Outstanding solvent and chemical resistance

NEW DU PONT TEFLON *Polytetrafluoroethylene*

TRADE MARK

COATED GLASS FABRICS, TAPES AND LAMINATES

Made of woven glass coated with tough Du Pont "Teflon," these new products are expected to find many uses in the electrical industry because of their unusual combination of valuable properties. For insulation in motors and generators, transformers and coils, special cable constructions and high-frequency electronic applications, "Teflon" Coated Glass Fabrics provide insulation meeting Class H requirements.

The table below shows electrical properties of typical single-ply "Teflon" Coated Glass Fabrics.

	[illegible]	[illegible]
Dielectric strength, short time, volts/mil.	>500	>500
Surface arc resistance, sec.	>240	>240
Dielectric constant, 60 to 100,000 cycles	2.8	3.0
Power factor, 60 to 100,000 cycles.	0.0005	0.0006
Volume resistivity, ohm-cm., room conditions	5×10^{11}	5×10^{11}
Insulation resistance, ohms (96 hrs. at 90% R.H., 35° C.)	10^8	10^8

High- and low-temperature resistance adds to the usefulness of these new Du Pont insulating materials. They may be used continuously at 200° C. or for shorter periods at 250° C., or at somewhat higher temperatures depending upon the time cycle. And, under normal conditions, they remain flexible at -87.5° C.

Excellent physical and chemical properties help make Du Pont "Teflon" Coated Glass Fabrics unusually versatile. Creasing, either parallel to fibers or diagonally, does not result in loss of good electrical properties . . . heat sealing can be accomplished at 750° F.

Although at the present time "Teflon" products are subject to allocation by the National Production Authority, you can now obtain "Teflon" Coated Glass Fabrics, Tapes and Laminates in limited quantities for experimental purposes. A standard line of single-ply materials and of laminates is available. For additional information, fill out and mail the coupon below.

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Fabrics Division, Empire State Bldg., New York 1, N. Y.

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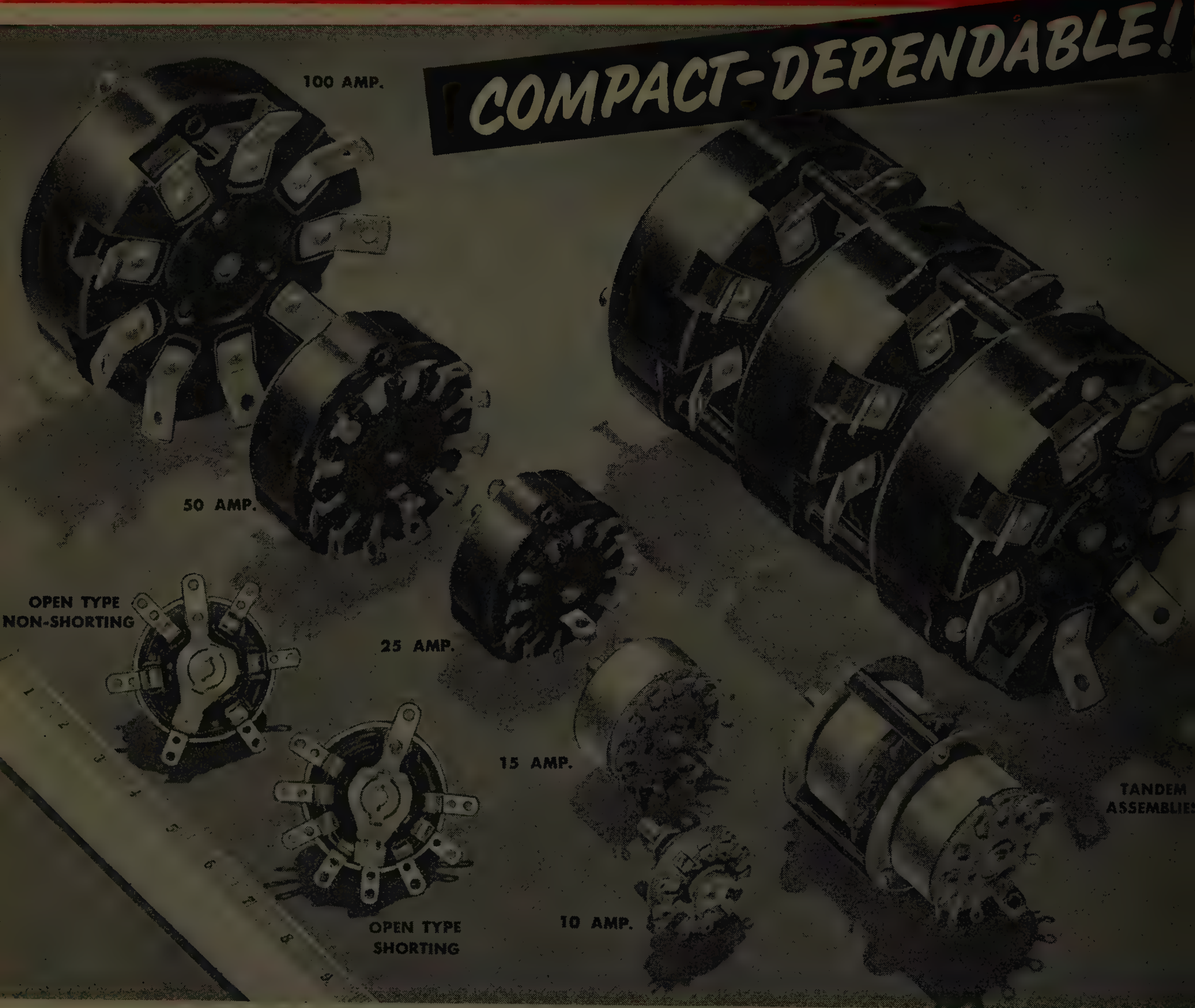
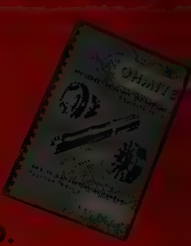


If you need a compact, high-current, all-ceramic, power-type, rotary tap switch, investigate the Ohmite line. Ohmite tap switches are particularly designed for a-c use. They are available in the single-pole, non-shorting type with up to 12 taps. The self-cleaning, silver-to-silver contacts require no maintenance. The rugged, one-piece ceramic body is unaffected by arcing. Ratings range from 10 to 100 amperes a.c. Two or three of these switches can be grouped in tandem to form multi-pole assemblies. Ohmite tap switches are also available in open-type models for both shorting and non-shorting applications.

Write on Company Letterhead for Catalog and Engineering Manual No. 40.



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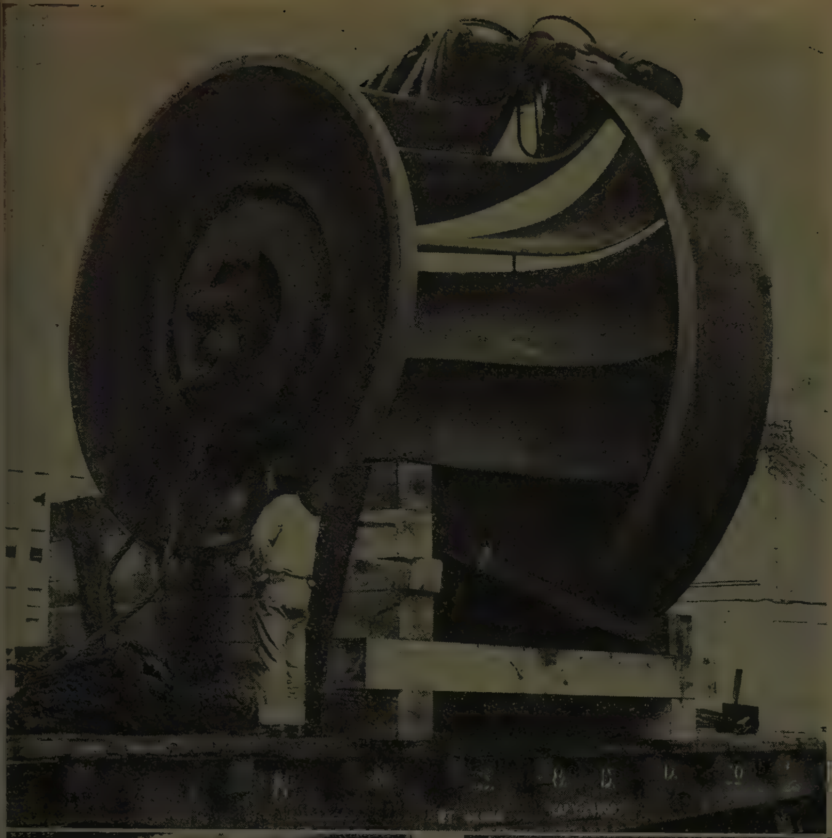

Over Eight Million Horsepower

The Newport News Shipbuilding and Dry Dock Company has received orders for the building of hydraulic turbines aggregating an output of 8,150,000 horsepower.

Left: Runner for the Buggs Island Development

Below: Assembly of spiral casings for the C. J. Strike Development

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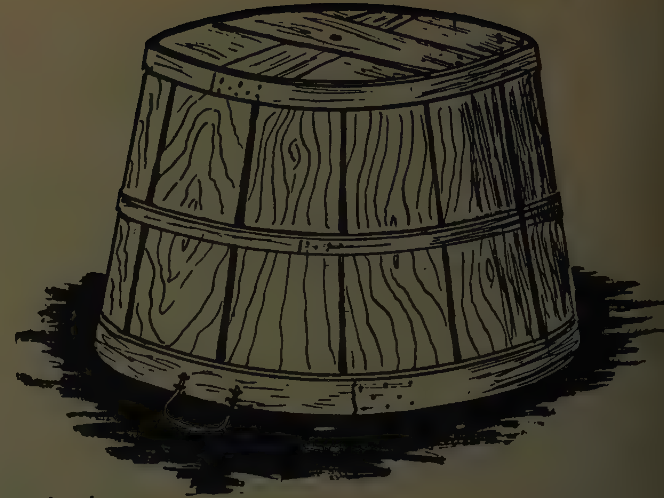

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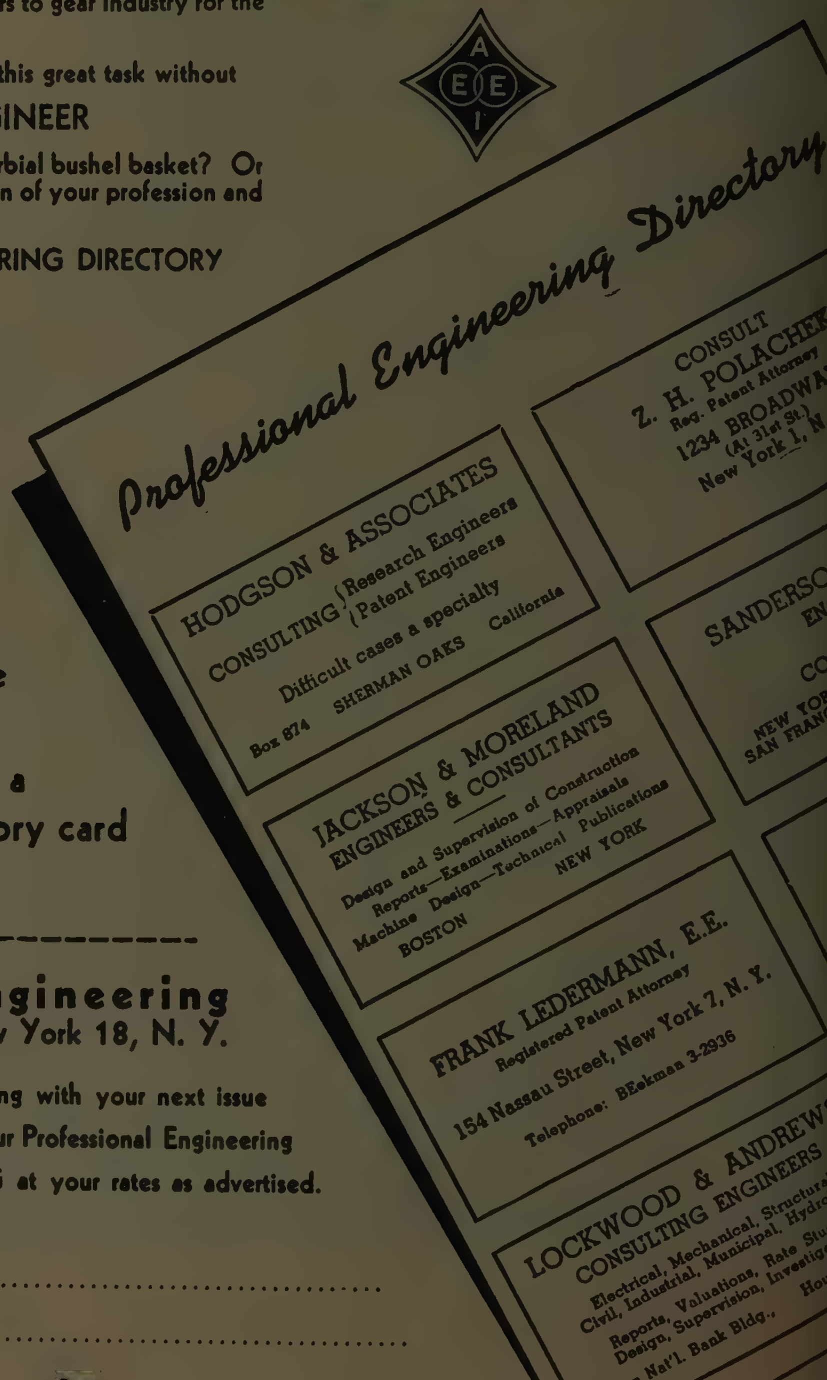

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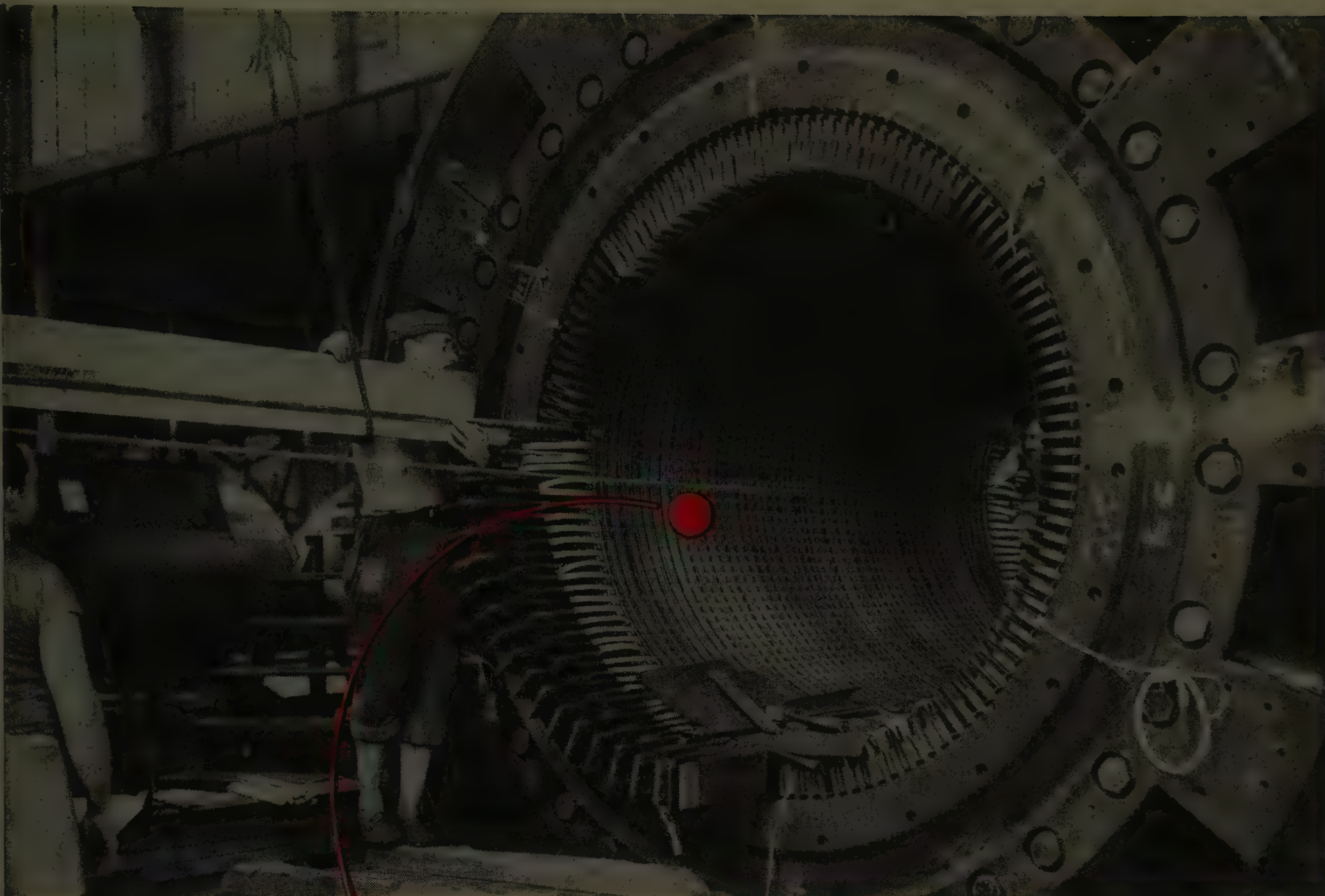

National

gave this generator brand-new power

In the illustration at the top of the page the coil bars are being drawn into position. The lower illustration shows the coils being connected to the leads. This 3-phase, 50-cycle, 13,800-volt generator develops 45,000-kva at 1500-rpm.

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COLUMBUS 16, OHIO, U. S. A.

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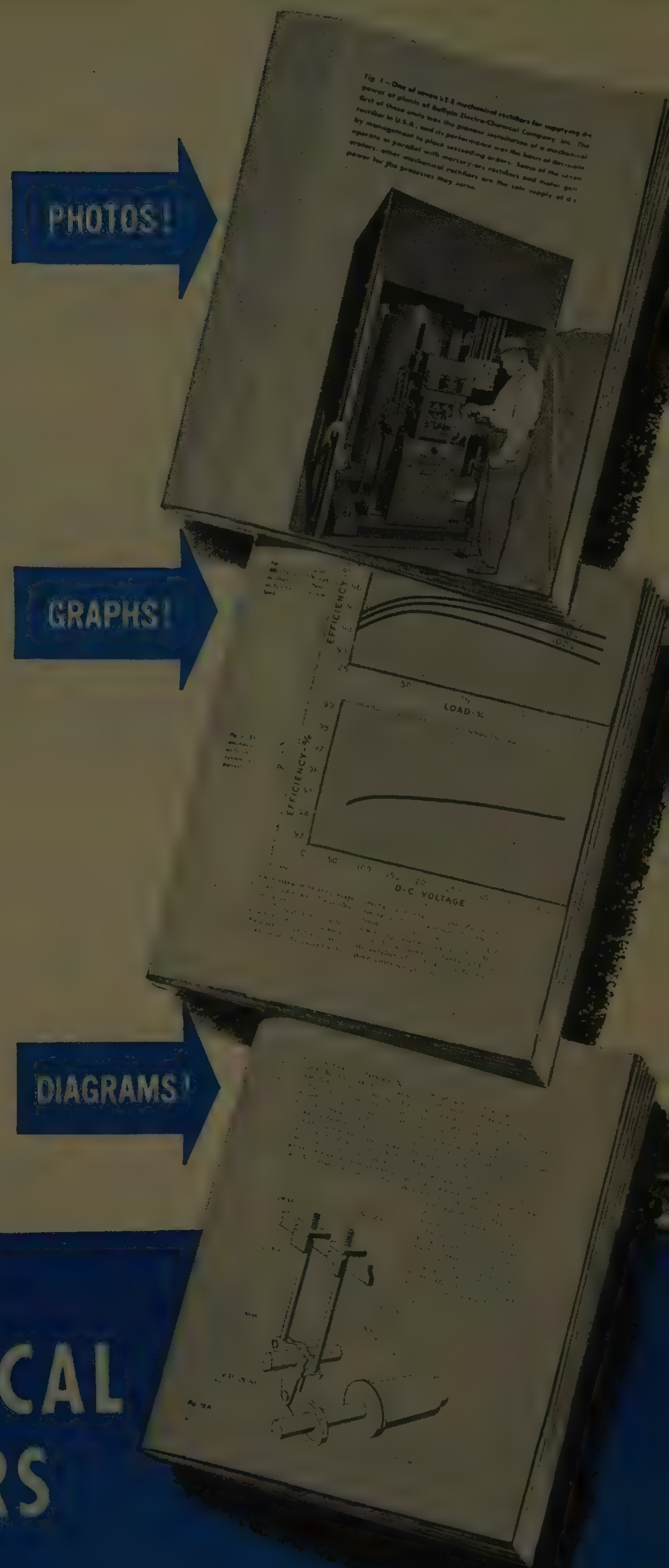

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ELECTRICAL ENGINEER, graduate, with at least five years' experience in the design and manufacture of polyphase squirrel cage induction motors, integral sizes to 100 HP. Must understand thoroughly the techniques and problems connected with pressure cast aluminum rotors. Salary open. Location, Ohio. Y-5866.

SALES ENGINEER, electrical graduate, 30–35, with electronic equipment sales experience covering pulse circuits, computers, etc., to call on government agencies, control and equipment manufacturers, and industrial firms. Salary, $7500–$8500 a year. Location, Brooklyn, N. Y. Y-6073.

SALES ENGINEER, 24–35, for established street lighting manufacturer. Must have at least two years' experience in Distribution Department of electric utility with street lighting system. Excellent opportunity. Territory, east Pennsylvania or New Jersey; will train in New England. Apply by letter giving full details of education, experience and salary desired in first letter. Y-6077.

ELECTRICAL ENGINEER, not over 35, to head relay department. Should have about five years' actual experience in relay work. Position is of supervisory nature and offers a great opportunity. Applicants should be from the Texas Gulf Coast area. Y-6101.

SALES ENGINEER to handle electrical apparatus and supplies for power and lighting applications. Excellent opportunity for young man interested in learning this business. Location, Maryland. Y-6116.

CHIEF ENGINEER with at least a B.S. degree, with at least ten years' progressive professional achievement as a creative electronic engineer and capable administrator. Must be experienced in development rather than pure research on the one side or straight production on the other, for company working in the field of applied research in electronics and development of electronics systems. Salary, $10,000 a year. Location, New Jersey. Y-6135.

ELECTRONIC ENGINEERS with design experience on d-c and wide band amplifiers, low power pulse circuitry, computers, telemetering or allied fields, for manufacturer of all types of instruments in the field of radioactivity. Should have had complete responsibility for design of complex electronic instruments in a manufacturing organization with supervision of junior engineers and technicians. Location, Massachusetts. Y-6196.

SENIOR ELECTRONIC ENGINEER, electrical graduate, experienced in design and development of radar and sonar equipment and apparatus necessary. Experience in design of UHF oscillators, amplifiers, oscilloscope deflection circuits. Will work on research projects. Salary, $6000 a year and up. Location, New Jersey area. Y-6207(a).

ELECTRICAL ENGINEER with five to ten years' experience, to take charge of electrical testing laboratory for company manufacturing wiring devices. Will be required to do some development and research. Salary open. Location, upstate New York. Y-6235.

ELECTRICAL ENGINEER for work involving the application of electrical equipment in various plant expansions. Will consider recent graduate, although some experience desirable. Salary open. Location, Ohio. Y-6237(a).

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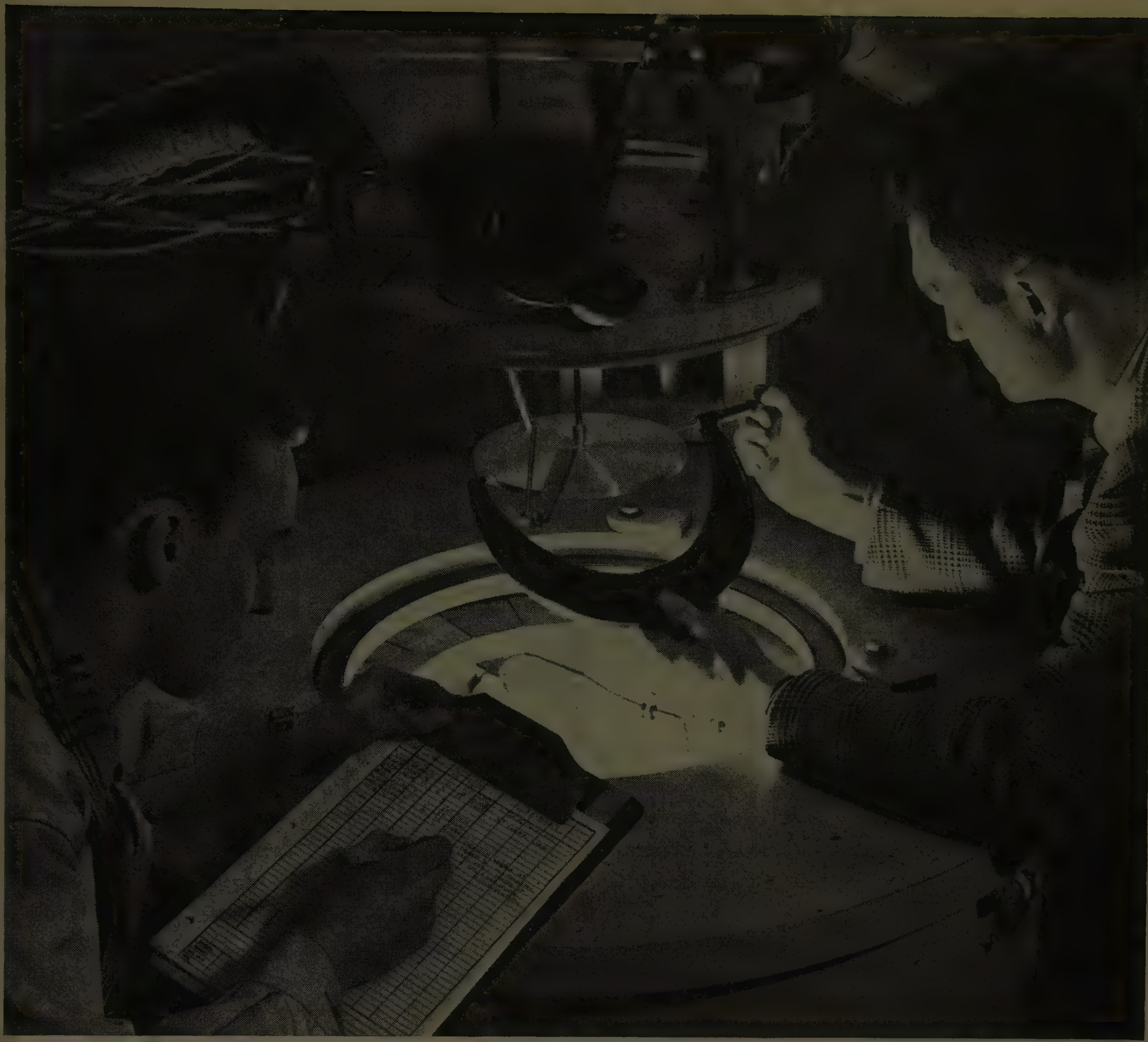
ENGINEERS. (a) Welding Engineer, engineering degree with at least two years' experience in arc or resistance welding around electronic equipment. Knowledge of electronic circuits. Duties will include setting up welding standards in resistance or arc welding projects and training personnel. Salary, to $7200 a year. Company may help on fee. (b) Maintenance Engineer, engineering degree, with at least five years' experience on maintenance and repair of welding equipment. Knowledge of welding equipment maintenance. Duties will include handling inert arc welding, a.c. arc welding, resistance welding, and d-c generating equipment. Will also handle normal electrical maintenance of manufacturing plant. Salary, to $8400 a year. Company may help on fee. Location, western Chicago suburb. R-8168.

PRODUCTION ENGINEER, electrical, to 40, with at least five years' experience either transformer design or production. Knowledge of Neon transformers or ballasts helpful. Duties will include production engineering, tooling, methods and processing, and possibly some design. Company will help on fee. Should be willing to transfer out of town later. Location, Chicago, Illinois. R-8203(b).

TEST PROCESS ENGINEER, electronic, graduate electrical, over 30, with five years' experience in electronics field. Will develop test process instructions in electronics field for testing department in shop. Salary, to $6000 a year. Location, northern Indiana. R-8292.



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GRADUATE ELECTRICAL ENGINEER wanted to join limited engineering group of electrical cable manufacturer. Position does not require prior experience in industry but does require an interest in working on a variety of projects including product research and development, manufacturing problems, and application engineering. Either power or communications training is appropriate. Some travel within United States on special problems. Location Connecticut. Good living conditions locally. Address: Box 216, ELECTRICAL ENGINEERING, 500 Fifth Avenue, New York 36, N. Y.

SENIOR ELECTRONIC ENGINEER—At least three (3) years post college experience in development, DC amplifier, digital computers, pulse and servo design. Established company, New York City. Write EE 1711, 221 W. 41 St., New York City 18.

HEAD OF ELECTRICAL ENGINEERING DEPARTMENT. Prefer PhD in E.E. although MS acceptable. Applicant should be specialist in electronics with some industrial experience. Beginning salary $5000–$6000 for eleven months service per year. This is entrance range and not top salary for such a position here. Applicant can be hired any mutually agreeable time now. Applicant should send outline of education, experience, references, etc. direct to Dean of Engineering, Colorado Agricultural and Mechanical College, Fort Collins, Colorado.

TWO SALES ENGINEERS wanted by large midwest electric utility. One with mechanical or electrical engineering background qualified for duties of power sales engineer. One with some engineering background to work on industrial development. Both men must be qualified to deal with industrial executives. Positions are permanent and salaried and would involve only occasional traveling. Give complete background and salary expected in your reply to Box No. 217, ELECTRICAL ENGINEERING, 500 Fifth Avenue, New York 36, N. Y.

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MASSACHUSETTS INSTITUTE OF TECHNOLOGY'S Digital Computer Laboratory of the Department of Electrical Engineering has staff openings for research and development engineers, physicists, and mathematicians, either with or without experience, for work involving logical design, theoretical analysis, component and circuit research and development (including work on transistors, ferromagnetic and ferroelectric memory cells, magnetic drums, transmission of coded information, and analogdigital conversion). Persons transferring from other fields to acquire experience in digital computers for engineering and military uses are encouraged to apply and may come on leave of absence from their permanent organizations. Position carries opportunity for academic study. Salary appropriate to candidate's experience and training. Address: Digital Computer Laboratory, MIT, 211 Massachusetts Avenue, Cambridge 39, Mass.

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ENGINEERS are needed for all branches of engineering including Aeronautical, Civil, Electrical, Electronics, Mechanical, Naval Architecture, Petroleum, etc. Positions are open in the Bureau of Standards and Civil Aeronautics Administration of the Department of Commerce, the Department of the Interior, the Federal Power Commission, the Navy Department, the Department of the Army, the Department of the Air Force, and other Federal agencies. Openings are located in Washington, D. C., Alexandria, Va., Arlington County, Va., and Montgomery and Prince Georges Counties, Md. Salaries range from $3,100 to $10,000 a year, depending upon grade assigned. The work includes such functions as (1) The design, development, or preparation of specifications for machines, equipment, power plants, and communication or transportation facilities, involving applications of theoretical and applied mechanics, and a knowledge of the strength and properties of materials; (2) Original research in one or more branches of engineering, developing engineering applications of physical and other scientific principles; (3) Engineering phases of mapping activities, such as land and hydrographic surveys, and the application of engineering techniques to map production; (4) Evaluation, investigation, or survey of engineering projects, structures, devices, or services. The difficulty of the work performed, responsibility assumed, and the extent of supervision exercised will vary with the grade of the position, increasing progressively in the higher grades. To apply for these positions, file standard form 57, which may be obtained from the United States Civil Service Commission, Washington 25, D. C.

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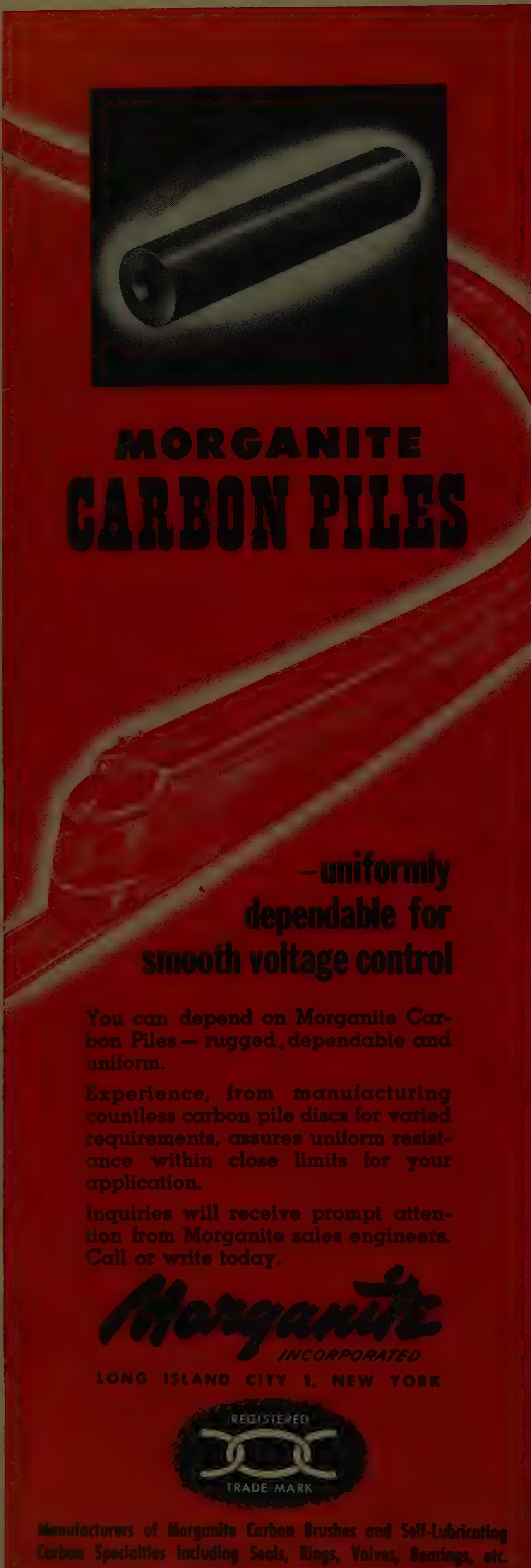

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